Computable General Equilibrium Modelling and the Evaluation of Agricultural Policy

by

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ABSTRACT

This thesis is concerned with computable general equilibrium modelling and evaluation of agricultural policy in a global context. Particular emphasis has been given to the EU's Common Agricultural Policy, reform of which was an important element in the successful conclusion of the Uruguay Round (UR), and which is to be subject to further reforms under Agenda 2000. Nevertheless, attention has also been given to modelling the effects of other Uruguay Round outcomes in manufactures and services, so that the reform of the CAP can be assessed within the liberalised global setting.

Chapter 1 describes the UR agreement in general, and the Agricultural Agreement in detail. Chapter 2 discusses the construction of computable general equilibrium models. This informs the consideration given in Chapter 3 to the Global Trade Analysis Project (GTAP) model and to results from several papers that use the model for the analysis of the UR, as well as other UR CGE models. The GTAP version 2 database is examined in Chapter 4 (the latest version, released in June 1998, is covered in Chapter 7). Chapter 5 gives attention to the finer detail of the standard GTAP model, and describes the modifications and extensions made to this model, such as the modelling of partially-specific-factors and endogenous subsidy rates and a means of decomposing welfare changes in the GTAP model. Chapter 6 presents the resuUs from modelling the Uruguay Round with the aggregation and model developed in Chapters 4 and 5. The main results for these simulations show that the global welfare gain and regional gains to the EU, the USA and Japan are comparable to studies discussed in Chapter 3.

Chapters 7 and 8 use the most recent GTAP database, which gives wider coverage of regions, sectors and factors than the version used in earlier chapters. Chapter 7 augments the model of Chapter 5 with production quotas for milk and sugar, explicit modelling of compensation and headage payment, intervention prices and support buying, and detailed representation of the EU export subsidy commitments. Chapter 8 reports the resuUs of simulations using this in a model 'projected' to 2005. The main resuUs are that the UR leads to welfare losses in the EU, which are partially reduced through Agenda 2000, and that in all scenarios, the redistributional impacts of reforms are far greater than the overall welfare changes. Finally, Chapter 9 offers some conclusions and suggestions for future research.

CONTENTS

CHAPTER 5: The GTAP Model and extensions to the model

CHAPTER 6: Results From The Uruguay Round Simulations

CHAPTER 7: **Modelling the Uruguay Round Commitments, Agenda 2000 and CAP Abolition in 2005**

CHAPTER 8: Applied General Equilibrium Results for the Uruguay Round Commitments, Agenda 2000 and CAP Abolition in 2005

CHAPTER 1

THE URUGUAY ROUND AND AGRICULTURAL POLICY

1.1 INTRODUCTION

The Uruguay Round (UR) multilateral trade negotiations are the most comprehensive and far-reaching negotiations in GATT history, with the final agreement of the Uruguay Round encompassing not only market access provisions for industrial goods, but also agreements on agriculture, textiles and clothing, services, investment, and intellectual property rights. In addition, the Uruguay Round provided for the formation of the World Trade Organisation (WTO), a permanent international body to regulate the enforcement of Uruguay Round provisions, provide a dispute settlement mechanism, and to oversee future trade negotiations.

This study examines the effects of the Uruguay Round on agriculture, with special emphasis on the consequences for agriculture in the EU. To this end, a computable general equilibrium (CGE) model will be developed to examine not only the effects of the agricultural reforms of the Uruguay Round, but additionally of liberalisation in manufacturing sectors, to assess the general equilibrium impact of the total impact of these reforms for each sector.

The background to the model is covered in the first three chapters of this thesis. This chapter discusses the Uruguay Round reforms, and concludes with points of interest to the modelling of tUe effects of the reforms on agriculture. Chapter 2 discusses the use of CGE models, and chapter 3 examines the main CGE models that have been used to simulate the effects of the Uruguay Round and discusses the results of studies that use these and other models.

Chapter 4 examines the Global Trade Analysis Project (GTAP) database, in particular looking at how the structure of agriculture and tUe structure of agricultural protection are represented in that database. Chapter 5 discusses the standard GTAP model, and makes additions to this model for the present study. Chapter 6 presents tUe main results of the simulations, and includes decompositions of these results to try to ascertain the impact of each major cause of the results, and the interaction between different reforms.

Chapter 7 presents a different model to chapter 5, based on the recent version 4 of the GTAP database, and models the Common Agricultural Policy more accurately. The focus of this study, and the results in chapter 8, is the forthcoming Agenda 2000 reform of the CAP.

Chapter 9 concludes, drawing comparisons between the two models presented hare and with other studies.

1.2 GATT HISTORY

In the 1940s, the International Trade Organisation was proposed as the third Bretton Woods body alongside the International Monetary Fund and the World Bank. The negotiations for the creation of the ITO took place between the Bretton Woods conference in 1944 and the Geneva conference in 1947, with discussions in three areas: the constitution of the ITO charter, multilateral tariff reductions, and general rules relating to tariff commitments. The agreement on the ITO charter was never ratified by the US Congress, so the ITO never came into operation, but the Havana Treaty on rules relating to tariff commitments became known as the General Agreement on Tariffs and Trade (the GATT)[1] with the multilateral tariff reductions coming into force as the first (Geneva) "Round" of the GATT. Subsequently, ftirther GATT Rounds were arranged, as shown in Table 1-1. Initially these Rounds were mainly concerned with the accession of new GATT members. The 1955-56 Geneva Round was for example, held to discuss the accession of Japan, and the 1960-62 Dillon Round included negotiations for the inclusion of the EEC in GATT.

[1] The GATT treaty itself was never presented for ratification to the US Congress, for fear that it would not receive the necessary two-thirds majority in the Senate. The GATT therefore only exists provisionally.

Table 1-1: GATT Rounds

		Number of Countries	Value of trade covered ($bn)	Average tariff cut (%)
Geneva	1947	23	10	35
Annecy	1949	33	n/a	n/a
Torquay	1950	34	n/a	n/a
Geneva	1955-56	22	2.5	n/a
Dillon	1960-62	45	4.9	n/a
Kennedy	1964-67	48	40	35
Tokyo	1973-79	99	155	34
Uruguay	1986-93	117		38

n/a = no general tariff reduction negotiations.

Successive Rounds have usually included more members, with LDCs participating in the Tokyo and Uruguay Rounds, and have taken notably longer to conclude. The Kennedy. Tokyo, and Uruguay Rounds centred around multilateral tariff reductions based on negotiated tariff-cutting formulae.

GATT Principles

The GATT rules, initially embodied in the Havana treaty but modified at later GATT Rounds, commits the Contracting Parties, or GATT members, to obey certain principles in their trade policies.

- The principle of *National Treatment* means that governments have a general obligation to treat domestic and foreign suppliers equally.

- *Most Favoured Nation* (MFN) treatment means that each GATT member must treat every other member on the same terms that it treats its most favoured trading partner. This means that any bilaterally agreed tariff reduction between two contracting parties must be applied to imports to those countries from ail other GATT members.

- *Open Markets* is a principle laid down in the GATT, meaning that all forms of trade protection other than import tariffs are prohibited, and that import tariffs sUould be reduced.

- The principle of *Fair Trade* involves the GATT's prohibition on the use of export subsidies.

- *Reciprocity* means that whenever a country lowers its tariff on imports from a second country, that second country must reciprocate by making an equal tariff reduction.

- *Tariff Bindings* are the key principle by which negotiated tariff reductions work, while allowing unilateral tariff reductions in excess of negotiated commitments. A tariff binding exists for each tariff line, and sets an upper limit on the applied tariff. Tariff bindings are reduced in each Round of negotiations, but where the applied tariff is much lower than the tariff binding, the former need not actually be reduced. Countries can apply lower tariffs than the binding, and if they do so they are then free to increase the applied tariff up to but not over the bound tariff. Tariff bindings can never be increased.

Exceptions to the GATT Principles

A number of exceptions have been made to these principles. The MFN principle has two exceptions: special and differential treatment for LDCs, and regional integration.

Special and Differential Treatment for LDCs has been a principle of the GATT since developing countries began to join the GATT negotiations at the start of the Tokyo Round in 1973. This treatment centres on two issues: a right to protect (because of infant industries, and the revenue implications of tariff reform), and a right to access. The right to access to developed country markets has been enshrined in the Generalised System of Preferences (GSP) by which, under the Tokyo Round agreement, developed countries may apply lower tariffs on imports from developing countries than the MFN tariffs applied to imports from developed countries. All developed GATT members have since given GSP preferences.

The right to protect is a mildly contentious issue, because proponents of free-trade argue that developing countries would be better off if the GATT forced them to make large tariff reductions. Partly because developing countries have been slow to join the GATT, special and differential treatment led in both the Tokyo and Uruguay Rounds to lower obligations for developing countries than for developed members. Specifically, the Uruguay Round commits LDCs to two-thirds of the reductions to which developed countries are committed. For reforms that developed countries are allowed a six-year implementation period, LDCs have a ten-year implementation period.

Regional Integration has been a permitted exception to the MFN principle since the accession to the GATT of the EEC as a group in the Dillon Round. Article XXIV permits free trade areas and customs unions so long as the trade barriers following integration are not higher than they were before integration[2], and so long as the regional trade agreement covers trade in all goods. The rules set out to include the EEC have been used more recently for the US-Canada Free Trade Area, the North American Free Trade Area (NAFTA) and other free trade areas.

Agriculture has prior to the Uruguay Round been essentially exempt from all the GATT rules and principles. The US negotiated an exemption under article XI of the original General Agreement for agricultural import barriers, which are permitted under certain circumstances, such as if imports threaten the workings of domestic farm income support programmes. Export subsidies are exempt where they do not lead to the exporting country gaining more than an "equitable share" of world trade in that product. These rules have been used by the US and EEC, and other countries, to maintain agricultural protection.

Emergency Action is an exception to the open markets principle, whereby a GATT member is allowed to temporarily increase import barriers if tariff commitments undertaken under the GATT have caused serious injury to domestic producers.

Balance-of-Payments reasons can be used to increase import barriers. Where a country is experiencing balance-of-payments difficulties, quantitative import restrictions can be used so long as they are temporary in nature and are relaxed when the balance-of-payments problems diminish.

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[2] If, for some commodities, tariffs after the formation of the customs union are higher than those applied previously, there must be compensation in terms of reductions in tariffs applied to other commodities. It should be noted that the regional integration provisions do not exclude integration where trade diversion is high, so a free trade area or customs union which lowers world welfare can be perfectly legal under the GATT.

Anti-Dumping Duties are permitted under the GATT where an exporting firm is selling goods at below cost-price in the importing country. The importer may then apply a duty that is equal to the price difference in addition to normal tariffs.

Countervailing Duties are permitted under the GATT where an exporting country is subsidising its exports to another country in violation of GATT rules on export subsidies. Such countervailing duties must only offset the export subsidy, so that the price of imports is the same with both the export subsidy and countervailing duty as it would have been without either instrument.

Export Duties and Export Quotas have never (prior to the Uruguay Round) been subject to GATT rules, primarily because they are rarely used in developed countries. The profusion of bilateral *Voluntary Export Restraints* in textiles and clothing during the 1960s and 1970s was instigated by developed countries to "persuade" developing countries to restrict the volume of their exports of textiles and clothing on a bilateral and product-specific basis.

1.3 THE TIMING AND POLITICS OF THE URUGUAY ROUND AGRICULTURAL AGREEMENT

The Uruguay Round began in September 1986 in Uruguay with the Punta del Este Ministerial Declaration, and concluded in December 1993, three years behind schedule. While other areas of negotiation, particularly services and intellectual property, were subject to disputes in the negotiation process, disagreements in the agricultural negotiations were primarily responsible for the delay in the conclusion of the Uruguay Round. For this reason, and to detail the background of the contentious areas, this chapter gives a commentary on the agricuUural negotiations.

The Initial Negotiating Positions

Table 1-2 shows the main points of the initial negotiating positions of the main participants in the agricultural negotiations, and these positions dominated the course of negotiations. The initial positions were submitted to the GATT in 1988.

Table 1-2: Main positions at the start of the agricultural negotiations

	United States	Cairns Group	European Community	Japan
Export Subsidies	Elimination over ten years	Elimination	Reductions where the EC is in surplus •	Elimination
Domestic Subsidies	Elimination, except for decoupled payments	Freeze, then reduce over 10-year period, with subsequent elimination	Aggregate reductions	No need for reductions
Import Barriers	Elimination	Elimination		Reductions, but retain import quotas

The US and the Cairns Group[3] both proposed dramatic reductions in agricultural protection. The US position was for the elimination of export subsidies and import barriers, embodying commodity-specific reductions in domestic support, with an aggregate measure of support, such as the producer subsidy equivalent (PSE), to monitor progress towards the eventual elimination of trade-distorting subsidies. Non trade-distorting subsidies (i.e. decoupled policies) could be retained. The Cairns Group had a similar agenda for the elimination of all trade-distorting domestic support and border protection, but with a ten-year phase-out period. The Cairns Group proposed the use of the aggregate measure of support (AMS) to monitor the reductions of domestic subsidies.

The EC position was largely a defensive effort to retain as much of the Common Agricultural Policy as it could. The EC proposed to use the AMS to make small reductions to domestic support, without any change in border protection. It proposed that because of the EC's system of variable import levies and variable export refunds, the reduction in domestic support would itself entail reductions in border protection, so no further reduction was necessary.

3 The Cairns Group is an independent negotiating group of agricultural exporting countries that tabled its proposals and offers in the agricultural negotiations collectively. Its members are: Argentina. Australia, Brazil, Canada. Chile. Colombia. Fiji. Hungary, Indonesia, Malaysia, New Zealand, the Philippines. Thailand and Uruguay.

The Japanese position was also defensive, in that Japan's main concern was to retain import quotas for rice. Japan therefore tabled offers to eliminate export subsidies and reduce tariffs, but to retain import quotas and make no reductions to domestic support.

The Main Negotiating Areas

In the area of export subsidies, the US, the Cairns Group and Japan all proposed elimination of export subsidies, but the EC, as the main user of export subsidies, proposed to keep them.

Import tariff elimination was tabled by both the US and the Cairns Group, with Japan proposing partial tariff reduction using traditional GATT procedures. The EC proposed that there be no changes to border protection.

Domestic support proved to be the key area of disagreement between the initial negotiating positions of the US and Cairns Group and the EC. While the US and Cairns Group envisaged total elimination of trade-distorting domestic support, the EC proposed partial liberalisation. The EC's domestic support proposals were also the keystone of its zero-reduction proposals on border protection, because of the way that doinestic reform would reduce the EC's variable border measures without any need for additional reform.

.\ further point of disagreement on domestic support reform was whether the PSE or AMS measures should be used to monitor reductions. PSE is defined as the net assistance provided to agricultural producers through market price supports and government expenditures, and is calculated on a commodity-specific basis. AMS is the aggregate PSE support over all agricultural commodities. Reductions in PSEs therefore imply liberalisation in every sector, while reductions in AMS mean liberalisation of support to agriculture as a whole, giving leeway as to the sectors in which the reforms take place. Canada tabled a proposal separately from other Cairns Group members that the AMS should exclude sectors where subsidies account for less than five percent of output.

The base year for reform also proved to be a source of disagreement. The period 1986-88 was one of historically low worid prices for agricultural products, with high levels of agricultural protection. Any reductions from this base would imply lower actual changes in protection than a reduction from a base such as 1990 that had higher world prices, and lower levels of protection. While protection levels vary inversely to world prices in all protecting countries, the EC's system of variable import levies and variable export refunds makes EC protection more sensitive to the choice of base year than that in countries that use fixed tariffs.

The Mid-Term Review, December 1988

At the Montreal mid-term review of progress, it became evident that a key stumbling block to the successful completion of the Uruguay Round negotiations was the US insistence on the one hand to eliminate trade-distorting protection, and the European Community's determination on the other hand to keep the Common Agricultural Policy intact.

The Geneva Accord, April 1989

The Geneva Accord marked a minor breakthrough in the agricultural negotiations, and was in part initiated because neither the US or EC wanted to see the breakdown of talks in other areas because of the impasse over agricultural reform. The Geneva Accord had no reference either to the elimination of trade-distorting support, nor to continuation of it, but rather contained the general objective of "substantial progressive reductions in agricultural support and protection sustained over an agreed period of time'. The Geneva Accord, partly in realisation of how far away agreement might be, included a freeze on all forms of farm support from April 1989 to December 1990.

The Framework Agreement, 1990

With the end of Uruguay Round negotiations timetabled for December 1990, the GATT negotiating group on agriculture released the framework agreement as a means of providing a basis for the final rounds of negotiations. The framework agreement itself tended more to the US and Cairns Group position than that of the EC in terms of border protection and export subsidies, but followed the EC proposals for gradual reductions of domestic support.

Breakdown of negotiations, December 1990

The US and EC were unable to come to agreement in the agricultural negotiations in 1990, and in December, at the scheduled conclusion of the Round, the US and other agricultural exporting countries withdrew from the Uruguay Round negotiations.

Some progress had been made in 1990 on domestic support, with the US and the Cairns Group tabling offers for 75% reductions in internal support and border protection, and 90% reductions in export subsidies over ten years. The EC had in turn made a specific offer to cut AMS by 30% over ten years from a 1986 base.

The main stumbling block for negotiations at this point was, however, the EC's insistence that reform of border protection was unnecessary if domestic support reductions were already to take place. The US and Cairns Group also wanted much greater cuts in export subsidies than the EC was prepared to accept, and insisted that domestic reforms should use the commodity-specific PSE calculation, whereas the EC insisted on using the AMS.

The MacSharry Reforms, January 1991 (revised July 1991)

With negotiations in the Uruguay Round suspended, EC Agricultural Commissioner MacSharry announced widespread reforms of the Common Agricultural Policy that would prove to be the crucial move in reaching agreement in the Round. The MacSharry Plan lowered support prices in the EC while supplementing farmers' incomes with compensating payments. Cereals producers were to set-aside a proportion of their arable land, for which they would receive additional compensatory aid.

The reductions of internal support prices were to bring internal prices closer to world price levels, reducing both import levies and export subsidies. While total domestic agricultural support was to increase, compensation payments and compensatory aid were eventually to be excluded from AMS calculations as non-trade-distorting policies. The MacSharry reforms therefore enabled the possible conclusion of the agricultural negotiations, and were to provide the means to complete the Uruguay Round.

The Dunkel draft agreement, December 1991

G;\TT secretary-general Arthur Dunkel tabled a draft agreement in December 1991, the main points of which became the foundation of the eventual agricultural agreement.

The Dunkel draft set out the principle of conversion of all non-tariff barriers to tariffs, and a 36% reduction in average tariffs, including those resulting from NTB conversion. Each tariff line would be subject to a minimum 15% cut, with additional tariff reductions where imports failed to meet a minimum market access commitment of 3% rising to 5% at the end of the implementation period. The implementation period for all market access provisions would be six years (1993-9), and the base period for minimum market access provisions would be 1986-8.

Domestic support reductions of 20% were envisaged by the Dunkel draft, on a uniform commodity-specific basis. "Green-box" policies that were not trade-distorting were exempted from reductions, and these included publicly financed R&D, early retirement schemes and land set-aside schemes (so long as land was withdrawn from production for at least three years). Additionally, "Amber-box" policies were exempt from reductions where subsidies were based on base period criteria rather than current prices and volumes. The "Amber-box" proposal was dropped by the time that the Agricultural Agreement was finalised, in part because they would enable support to farmers that had produced a certain commodity in a base period even if farmers no longer produced that commodity.

The Dunkel draft proposed reductions of 36% on export subsidy expenditures by commodity, with a minimum reduction of subsidised export quantities (also commodity-specific) of 24%.

While the Dunkel draft introduced many changes that would be included in the final Agricultural Agreement, there were several areas that still lead to disputes between negotiating countries. The EC was opposed to restrictions on the volume of subsidised exports and was unable to accept the domestic support proposals, which did not exempt compensatory payments from reduction and therefore were at odds with the recent MacSharry reforms. The US also wanted deficiency payments to be excluded from domestic reductions. The EC, Japan and Canada all wanted to retain the ability to impose quantitative restrictions on imports.

The Blair House Agreement, November 1992

The Blair House agreement was a bilateral agreement between the US and EC. The most crucial agreement at Blair House was the creation of a "Blue-Box" category for exemption from AMS support reduction, to include all direct payments under production-limiting programmes. This exempted both US deficiency payments and EC compensatory payments. Additionally the commodity-specific PSE reductions entailed in the Dunkel draft were changed to a 20% reduction in the aggregate measure of support. These two issues effectively enabled EC agreement by making an Agricultural Agreement that could be fulfilled by the MacSharry reforms, because (a) although the MacSharry reforms increased the overall AMS. they reduced the AMS if compensatory payments were excluded, and (b) the MacSharry reforms did not reform some sectors (such as sugar and dairy), so that the specification of aggregate reductions was necessary.

A Peace Clause was also agreed at Blair House, whereby countervailing actions were ruled out for agricultural commodities during the implementation period. This gave the EC even more leeway in how it implemented the Agricultural Agreement, as no action could be taken against them for non-compliance for a period of six years.

The Final Agreement on Agriculture, December 1993

While the Blair House agreement cleared up most of the remaining areas that were blocking negotiations after the Dunkel draft, there were also several other country-specific concessions before the final agreement was reached, the most important of which was the allowance for Japan and South Korea to retain quotas on rice imports.

1.4 COMPONENTS OF THE FINAL URUGUAY ROUND AGREEMENT

The components of **the** final agreement are **examined** individually in this section. Section 1.4.1 **examines Uruguay** Round **market** access provisions for **manufactured** goods. Section 1.4.2 examines the Agricultural Agreement, secfion 1.4.3 the textiles and clothing component of the Uruguay Round agreement, and section 1.4.4 other issues. The grouping of services, investment, intellectual property, and other issues into the same group does not reflect the fact that these issues are less important than those examined individually, but rather that because market access, agriculture, and textiles and clothing reforms rely predominantly on reductions in tariffs, subsidies and export taxes, they lend themselves to quantitative modelling. This study, and most of the studies discussed in chapter 3, will simulate the effects of these reforms and ignore those that are in the 'other' issues of section 1.4.4

1.4.1 Uruguay Round Market Access Provisions For Manufactures

Market access provisions can be considered to be the basis of GATT Rounds; in all Rounds before the Uruguay Round, market access provisions were the only major reforms initiated. Uruguay Round market access provisions are based on the elimination of non-tariff barriers (replaced by equivalent tariffs), and average tariff reductions of 38% (including the reduction of tariffs that were converted from non-tariff barriers), with LDCs being allowed smaller reductions of 24%. A small number of products were excluded ('zero-rated') so the average reduction will be slightly lower than these rates. GATT signatory countries submitted new tariff schedules that complied with the provisions, and had some leeway in how the individual tariff cuts were implemented. The tariff schedule submissions total 22,000 pages. The tariff reductions must occur during a six year implementation period from 1994 (ten years for LDCs).

Tariff Bindings and Applied Tariffs

Tariff bindings are commitments that a country makes to not increase a tariff above the bound level, and these are administered under GATT/WTO as countries submit the tariff bindings in each successive GATT round; countries cannot of course increase the bindings "in between" Rounds - the pre-UR binding must be equal to or lower than the binding after the Tokyo Round reductions. While tariff bindings were reduced as a resuU of the Uruguay Round, applied tariffs would not necessarily fall where the previously applied rate was lower than the pre-UR binding. While in industrial economies 94%[4] of imports were subject to tariffs that were binding (i.e. the applied tariff was equal to the bound tariff) before the Uruguay Round, only \3% of tariffs were bound in developing countries, and 74% in transition economies. As a result of the Round, the percentage of imports that are subject to bound tariffs increased to 99% (developed), 61% (developing) and 96% (transition). For developing countries in particular a large part of the negotiated tariff binding reduction will lead to no reduction in applied rates as the "slack" between bound and applied rates is reduced.

Safeguards and exceptions

The Uruguay Round Agreements included numerous exceptions, many of which were included in previous Rounds. Custom surcharges and fees (which are really tariffs, but often with different justification and implementation) are exempt from any reductions - and are substantial in LDCs - they are sometimes more than 50% of the tariff rate.[5] LDCs can also apply non-tariff barriers under certain circumstances to avoid balance-of-payments problems, but must provide justification as to why price-based measures are not an adequate instrument to deal with the balance of payments problem. Safeguards allowing the application of non-tariff barriers to protect a domestic industry from injury caused by a sudden increase in imports have been discontinued. Any currently operating safeguards under this clause must be terminated within five years, or within eight years of the date the safeguard action was originally taken, whichever is the sooner.

Anti-Dumping and Countervailing Duties

Contingent protection in the form of anti-dumping duties and countervailing duties is permitted after the Uruguay Round, but only if a cause for the protection can be proved to the WTO. Anti-dumping duties entail countries imposing specific tariffs on products produced by a specific firm where it can be proved that that firm is deliberately attempting to undercut prices in the importing country. Historically it has

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4 Tariff binding data from de Paiva Abreu (1995) and Francois et. al. (1995a). both taken from GATT sources.

5 Francois et. al. (1995a) give this figure, referring to individual GATT Trade Policy Reviews. No comprehensive data exist on surcharges and fees.

been relatively easy to 'prove' that a country is being harmed by dumping actions because of the absence of any international standards. The creation of the WTO as an overseer of anti-dumping must therefore be seen as an improvement in the regulation of these actions. However, anti-dumping activities are predicted to increase.

Countervailing duties are additional tariffs that can be applied to a product where the exporter of that product is providing an export subsidy higher than that permitted by the Uruguay Round Agreements. As such, countervailing duties are not only permitted by the Uruguay Round, but are included as a means of punishing export subsidisers who break Uruguay Round subsidy rules. The application of these duties is overseen by the WTO dispute mechanism.

1.4.2 The Agricultural Agreement

The Agricultural Agreement is based on the same principles of liberalisation as the market access agreement, but is particularly notable because agriculture was never included in GATT negotiations prior to the Uruguay Round, except for limited agreements on dairy products and bovine meat. The reason for the exclusion of agriculture in previous Rounds is mainly political: most of the developed countries that set up the GATT. and were the main participants of previous Rounds, had high levels of agricultural protection that they intended to keep. The inclusion of agricultural liberalisation in the Uruguay Round was the result of three main factors. Firstly, the USA. which had tended to be a proponent of agricultural protection in the pre-war period, has been in favour of liberalisation in the 1980s and 1990s. Secondly, the European Union (then the European Economic Community), while still being in favour of agricultural protection, came under pressure for reform to prevent large visible surpluses and to make the CAP budget more controllable. The main reason for CAP reform, though was the need to make GATT agreement possible:

> *"There were good internal reasons for reforming the CAP in the early 1990s, and some elements of the MacSharry reform ... have responded to these internal reasons. However, the major political force behind the MacSharry reform, as far as I can see, was the need to prepare the CAP for a GATT agreement on agriculture."* Tangermann (1998 p. 25)

Table 1-3: UR-AA Reductions in Agricultural Support and Protection (1995-2000)

	Commitments	Qualifications/Exemptions
Domestic Support	20 per cent reduction in total Aggregate Measurement of Support (AMS) over 6 years from 1986-88 base (price support measured against Fixed External Reference Prices (FERPS) Credit for reductions since 1986	Green Box Instruments exempt (e.g. R&D) Direct Payments under production limitation programmes (blue box instruments) exempt (e.g. EU compensation payments, US deficiency payments) Special provisions for developing countries
Market Access	All NTBs converted to tariffs. No new NTBs to be created All base period tariffs including NTB equivalents to be reduced by an unweighted average of 36 per cent over 6 years from 1986-88 base (tariffs measured against FERPS) Minimum 15 per cent reduction in each tariff line All tariffs bound at end of implementation period Minimum access provision of 3 per cent rising to 5 per cent of base period consumption. Base period imports count toward access requirement. Minimum access provision cannot be cut below actual base period import level.	Country specific derogations (e.g. Japan and Korea to postpone tariffication of rice imports until 2000) EU 10 per cent Community Preference Margin Special safeguards Special provisions for developing countries

Source : Ingersent. Rayner and Hine (1995)

The third reason for the inclusion of the Agricultural Agreement in the Round is that agricultural exporting countries were more prominent in the negotiations than in previous Rounds. This is partly due to increased numbers of LDC participants in the GATT. and partly because small agricultural exporting countries applied greater pressure on the agricultural protectionist countries by negotiating under the banner of the Cairns Group.

The Agricultural Agreement included agreements on liberalisation in three main areas: market access for agricultural goods, agricultural export subsidies, and domestic producer subsidies of agriculture. Each area has its own set of exceptions.

Agricultural Market Access

Like market access in industrial products, agricultural market access was founded on the principles of tariffication. national treatment and tariff reduction. Tariffication is the elimination of non-tariff barriers and their replacement with equivalent tariffs. Tariff reductions require average 36% (24% for LDCs) tariff cuts (including reduction of converted non-tariff barrier tariffs) for agricultural goods over a six year (ten years for LDCs) implementation period. Least developed LDCs are exempt from these requirements. Each individual tariff line must have a 15%) (10% for LDCs) reducfion in tariff binding.

In addition, a minimum market access commitment of 5% (rising from 3% from the start of the implementation period) is applied to products that were previously subject to non-tariff barriers. If imports are below this level of total demand, further tariff cuts must be made to ensure the minimum market access commitment is met. No commitment exists for products where no non-tariff barriers existed prior to tUe Uruguay Round implementation period, however high tariff levels were.

Dirty Tariffication

Agricultural tariff reductions, like industrial tariff reductions, are reductions of tariff bindings, so that where an applied tariff is below Us tariff binding, the applied tariff reducfion may be lower than 36% (indeed, the applied tariff may not necessarily be reduced at all). Agricultural tariff reductions have been to some extent watered down by "dirty tariffication". Because agriculture was never before subject to GATT disciplines, there was no necessity for countries to have tariff bindings for agricultural products prior to the Uruguay Round agreement (although a few countries did bind some products voluntarily). Indeed, many agricultural products were subject to protection through non-tariff barriers, so tariff bindings would not have been enforced anyway. As part of the Agricultural Agreement, signatory countries therefore submitted their own tariff bindings, which were based on tariff levels (or in the case of NTBs, the estimated difference between internal and world prices) in the base period 1986-88. Because this period was one of low world prices for agricultural products, the resulting tariff bindings were in many cases very high. For most agricultural products, the tariff binding after the 36% reduction is still much higher than applied tariffs after tariffication of non-tariff barriers. Hathaway and Ingco (1995) estimate that, for most countries, the Uruguay Round agricultural tariff reductions will lead to reductions in applied tariffs for only a few products (for the EU, wheat, rice, coarse grains, sugar, most meats, oilseeds, dairy and wool will have no reduction in applied tariffs)."

Given the limitations imposed by dirty tariffication, it is unlikely that the agricultural tariff reforms in themselves will lead to much liberalisation. In the long run, the elimination of non-tariff barriers and the setting of bound rates to be reduced in future Rounds may prove to have a greater liberalising impact. The minimum market access commitments may also lead to greater tariff reduction than the tariff binding reductions.

Exceptions to the Market Access Provisions

A special safeguard of the Agricultural Agreement allows countries that previously applied non-tariff barriers to levy additional tariffs above the scheduled levels where a surge in imports or a dramatic fall in border prices threatens to undermine the position of domestic producers.

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[6] For import of cereals into the EU. the duty paid import price has got to be less than to or equal to the effective intervention price multiplied by 1.55. The system is essentially similar to the traditional VEL/threshold price system.

An additional exception to the tariffication provisions is designed specifically for Japanese rice imports, but may be used by any country on a product that meets the criteria for 'special treatment'. Such products must have had non-tariff barriers before the implementation period, imports must have been less than three per cent of domestic consumption in the 1986-88 base period, the product must not have had export subsidies since 1986, and measures to restrict domestic production must be applied to the product. Where these conditions are met (this will probably only be for rice imports in Japan, and possibly Taiwan and South Korea), non-tariff barriers can be maintained (during and after the implementation period) subject to a minimum market access provision of 4%, rising to 8% by the end of the period. Although this 'special treatment' contravenes the GATT principle of tariffication, it does ensure that liberalisation occurs in these products, as market access must be below 3% for special treatment to be allowed, and this must rise to at least 8% by the end of the implementation period.

Agricultural Export Subsidies

Agreement on the treatment of agricultural export subsidies was one of the most difficuU issues of the Uruguay Round negotiations. While the USA originally wanted the complete elimination of export subsidies, the final agreement is less comprehensive. Direct export subsidy expenditure must be reduced to 36% below the expenditure in the base period of 1986-90 over a six-year implementation period. The quantity of subsidised exports must also be cut by 21 per cent (with the same base and implementation periods).[7]

While the export subsidy commitments are product-specific, the agreement allows different product lines to be aggregated together when computing expenditures and quantities. Thus the EU included 40 different product lines as coarse grains, and some substitution will necessarily occur between these products.

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7 A front-loading provision applies particularly to EU wheat and beef: if the 1991/2 exports were higher than the base level, and allows the quantity reductions to start from a higher point. This does not affect the final export subsidy commitments.

Domestic Agricultural Support

The Agricultural Agreement limits expenditure on domestic agricultural support; the Aggregate Measure of Support (AMS) must reduce by 20% over the six-year implementation period. The AMS is defined as the producer subsidy equivalent of support over all commodities.

Exceptions to Domestic Agricultural Support Provisions

Domestic support policies that are not trade-distorting can receive "Green box" exemptions from AMS reductions. These include publicly-funded R&D programmes, retirement programmes, and land withdrawal programmes where land is withdrawn from production for a minimum of three years. "Blue Box" policies are also exempt where subsidy payments are made as part of a production limitation programme. Both EC compensatory payments and US deficiency payments are covered by this provision.

1.4.3 Textiles and Clothing in the Uruguay Round

Trade in textiles and clothing, which since the 1960s has been dominated by the Multi-Fibre Agreement (MFA), is to undergo dramatic liberalisation after the Uruguay Round. The MFA regulates world trade in textiles by placing quantitative restrictions on exporting countries, by means of bilaterally negotiated voluntary export restraints (VERs). While voluntary in name, these instruments force exporting countries to limit their exports of clothing and textiles to developed countries, with the threat of more stringent sanctions against the exporting country if it fails to restrict imports to within its allocated quota. The importing countries (the US. Canada, the EU. and EFTA countries) get protection for their domestic industries without having to break GATT rules by imposing import quotas or by illegally increasing tariffs. The exporting countries prefer VERs to import quotas or tariffs because the quota rent (or tariff revenue) that would occur with these policies is transferred to the exporter by means of higher prices. VER volumes increase each year by specific growth rates.

The MFA ensures that the predominant exporters during the 1960s (Hong Kong and Singapore) receive protection from competition from newly emerging suppliers (such as India. Pakistan, and China), because the VER volumes are derived from the initial volumes set in the 1960s. The least developed countries of sub-Saharan Africa are exempt from MFA restrictions, but constitute a very small proportion of world clothing and textile exports.

The Uruguay Round Agreement includes a basic commitment to return textiles and clothing to full GATT disciplines over a ten year period. This means that the MFA system of VERs will be phased out over a ten year period between 1995-2005. The phase-out will occur in three stages: in stage 1, starting in January 1995, VER growth rates are increased by 16%. Stage 2 starts in January 1998, and during this stage growth rates are increased by a further 25%. In stage 3 (January 2002) growth rates are increased by a further 27%.

In addition to VER growth acceleration, each importer must fully include 16% of products into GATT/WTO disciplines in stage 1. a further 17% in stage 2, and a further 18% of products during stage 3. These products must then be completely free of VERs. As it is at the discretion of the importing country on which products to eliminate VERs, it is likely that they will include products with lower potential imports during the initial stages, and leave the products with larger potential imports to the end of the phase-out period.

By 2005, 51% of those product categories[8] subject to VERs in 1995 will therefore be free from MFA constraints, and the remaining 49%) of categories will have high levels of quota due to the accelerated growth rates. It is likely that for many of the categories still subject to the MFA the quota will not be binding, that is the exporter is exporting below the VER quota level. All VERs will be eliminated in 2005 whether or not they are binding at the time.

Tariffs on textiles and clothing are subject to normal market access commitments, that is (a) any existing non-tariff barriers must be replaced by tariffs, and new NTBs cannot be introduced, and (b) tariff bindings must be reduced according to the schedules submitted as the annex to the Uruguay Round agreement, within the 38% reduction in average tariffs on industrial goods as a whole. However, a safeguard

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[8] This applies to different product categories for each importer-exporter pair. Note that the MFA is extremely product specific; typically men's light-blue long-sleeved shirts have different quotas than men's dark-blue long-sleeved shirts.

agreement appended to the textiles and clothing reforms permits the introduction of additional tariffs on textiles and clothing where damage occurs to the domestic industry, and that damage is directly attributable to the MFA phase-out. Safeguards are degressive (they come into effect 3 years after the damage occurs to the domestic industry), and they must not reduce imports below the level of imports that existed twelve months before the safeguard came into effect. There is some uncertainty over how the MFA elimination will operate in 2005. Whalley (1995) argues that developed countries may resort to WTO safeguard and anti-dumping measures to continue to protect their clothing industries.

Table 1-4: Examples of VER Growth Rates in the Phase-Out Period

			Established Growth rate of 3%		Established Growth rate of 5%		Established Growth rate of 6%	
Stage of integration	Year	Growth Factor	Growth Rate	Quota	Growth Rate	Quota	Growth Rate	Quota
	0			100		100		100
Stage 1	1	16%	3.48%	103.5	5.80%	105.8	6.96%	107.0
	2		3.48%	107.0	5.80%	112.9	6.96%	114.4
	3		3.48%	110.8	5.80%	119.5	6.96%	122.4
Stage 2	4	25%	4.35%	115.5	7.25%	128.2	8.70%	133.0
	5		4.35%	120.5	7.25%	137.5	8.70%	144.5
	6		4.35%	125.7	7.25%	147.4	8.70%	157.1
	7		4.35%	131.2	7.25%	158.1	8.70%	170.8
Stage 3	8	27%	5.52%	138.4	9.21%	172.7	11.05%	189.7
	9		5.52%	146.1	9.21%	188.6	11.05%	210.6
	10		5.52%	154.1	9.21%	205.9	11.05%	233.9

source: Whalley(1995)

Table 1-4 shows examples of how the VER phase-out effects VER quotas, and it is clear that the VER growth formula will disproportionately benefit those exporters that already have high VER growth rates. Despite the fact that it is the emerging textiles and clothing producers that have the higher growth rates, given that the quota levels for these exporters are relatively small, it is likely that newer exporters such as India, China, Bangladesh, Indonesia and Malaysia will still be quota-constrained on many lines of textile and clothing exports by 2005.

The Expected Effects of the MFA phase-out

The MFA phase-out will liberalise trade in developed countries, and so should increase static long-term welfare there, but will probably lead to reductions in production of textiles and clothing in MFA importing countries. There will therefore be some welfare losses due to the transition as workers are displaced from these industries, but the size of the (discounted) static welfare gains appear to be large enough to outweigh these.

The position for exporting countries is mixed. Traditional exporters such as Hong Kong. Singapore, and East European exporters have large quotas that protect them from competition from emerging producers. The large increase in world exports that should result from the MFA phase-out will reduce world prices and reduce the export earnings of these countries. These countries will not necessarily have welfare losses from the reforms, however, because the MFA phase-out will reduce domestic distortions within exporting countries: it will remove the export-bias that exists within textiles and clothing industries in exporting countries, leading to increased welfare from lower consumer prices. The phase-out will also reduce distortions due to the inefficiencies in production that may occur through the process by which export quotas are allocated to exporting firms.

The exporters that will clearly gain from the phase-out are those whose exports are heavily constrained by the MFA. Large Asian countries that are emerging as clothing producers will have welfare gains as they will be able to export a large proportion of world trade.

The least-developed countries of sub-Saharan Africa that have previously exported textiles and clothing without quota restraints will lose from the agreement, as world prices will fall as competition is opened up from lower-cost suppliers. Because these countries did not have VERs in place, they will not have welfare gains from the removal of domestic and production distortions, so these countries will unequivocally suffer welfare losses.

1.4.4 Other Aspects of the Uruguay Round Agreement

Several other areas were included in the Uruguay Round that were new to GATT trade negotiations. The General Agreement on Trade in Services (GATS) brings services trade within GATT/WTO disciplines by extending the most-favoured nation principle to such trade. The agreement also includes a general obligation to provide equal treatment for national and foreign service suppliers (the national treatment principle), and requires transparency in laws and regulations concerning services. GATT/WTO members are also required to develop national schedules of market access commitments for services, and may begin tabling offers for further negotiation immediately. This allows the next WTO negotiations to treat services liberalisation in a similar manner to market access for manufactures trade.

Agreement in the area of trade-related intellectual property rights (TRIP) extends intellectual property rights on the same basis to all GATT/WTO member countries. This area was a key negotiating area for the US, which was keen to stop international fihn, music and computer software piracy. The basic principle of the TRIP agreement is most-favoured nation treatment of intellectual property, so if a country recognises legal copyright from one foreign country, it must recognise it from all GATT/WTO members. An important concession to developing countries, who opposed the TRIP agreement, is that they have a longer period of time before the agreement affects them: developed countries must bring domestic legislation into conformity with the agreement within one year, developing countries and economies in transition have a five-year transition period, and the least developed countries have an eleven-year transition period.

The Trade-Related Investment Measures (TRIM) agreement centred on the basic principle that rules governing international investment should be consistent with the GATT principles of national treatment and prohibition of quantitative restrictions. A list of TRIMs that violate these rules was included, and countries have a period of two years (developed countries), five years (developing countries) or seven years (least developed countries) to ensure that the listed TRIMs do not break these principles.

Finally, the creation of the World Trade Organisation may prove to be the most important aspect of the Uruguay Round. The WTO is a permanent body, with the tasks of administering the global trade system, administering the dispute mechanism procedures, administering the two-yearly trade policy review, and providing a forum for discussion and negotiation for future multilateral trade liberalisation. Importantly, a resumption of the agricultural negotiations is scheduled to begin at the end of 1999 to realise the long term objective of "substantial and progressive reductions in support and protection resulting from fundamental reform" (article 20 of the Uruguay Round Agricultural Agreement).

1.5 CONCLUSIONS

Several issues for analysis are raised by the Uruguay Round. The more obvious ones that have been addressed by several authors are questions such as: how large are the welfare gains from the Uruguay Round? How are the welfare gains distributed between regions? How much of the welfare gains is contributed by different areas of the agreement?

Other issues that are pertinent to EU agriculture are: what are the price, production and welfare effects for EU agriculture? Can the reformed CAP meet the Uruguay Round requirements? Which aspects of the Agricultural Agreement are the most important?

These issues will be ftirther discussed in chapter 3 (results from other studies) and chapter 6 (results from this study).

CHAPTER 2

COMPUTABLE GENERAL EQUILIBRIUM MODELLING

Although many of the principles of computable general equilibrium (CGE)[1] modelling have been known for a long time, the advances in computer power over recent years have dramatically increased the applicability of the CGE approach to economic modelling. Now, complex models can be run on most personal computers, and this capability has greatly expanded the volume of research employing CGE models.

CGE modelling is a simulation-based approach to policy analysis, whereby a model is built and calibrated to data, and then simulated policy changes are enforced on the model. The results of these simulations are then given as levels or changes in quantities (output and demands) and relative prices. The numerical nature of simulations means that results can only be obtained for specific policy changes, and that no general proofs of results can be obtained.

The attractions of the CGE approach lie in the fact that it can incorporate all the feedback effects in the economy. In terms of trade policy modelling, this means that the concept of effective protection is directly incorporated into the analysis, with feedback effects coming from uses of imports as intermediate goods, competition for factors, demand substitution (and complementarity) and government budget effects. Thus the effects of a trade policy issue can be examined directly in terms of resource flows between sectors without the need to take account of these effects in any additional calculations. Hertel (1993) uses a small model to show that a partial equilibrium model is inadequate for simulations where multi-sector reforms are taking place. Moreover, he shows that while a partial equilibrium model performs as well as a general equilibrium model when single-sector reforms are modelled, the effects of

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[1] Some economists prefer the term "Applied General Equilibrium" (AGE)

the reforms on other sectors may be significant, and in such cases are necessarily missed by partial equilibrium modelling.

CGE models also benefit from not being tied to direct functional relationships between policy instrument and target. Because no equations are solved in their general form to give a solution for the target as a function of the instruments, CGE models do not suffer from some of the constraints of other approaches, such as partial equilibrium and macroeconomic models. Where these models can usually only be applied to marginal changes, CGE models can be applied to discrete changes in many policy variables at the same time. CGE models can also incorporate a variety of constraints into the form of the model, thus being able to model quantitative restrictions with comparative ease.

CGE modelling does however contain several disadvantages when compared to other modelling approaches. The complexity of data requirements necessitates intensive data gathering and manipulation. Because the complexity of the data required generally prohibits their being available as time series, CGE models ace based on a data set for one year only, or in the best case on averages of a few observation periods. This constraint makes empirical testing of functional forms infeasible. and thus casts considerable doubt on the accuracy of CGE results.

CGE models tend to be very weak in the area of macroeconomic closure: typically all markets are assumed to clear, and tUis assumption is imposed on the benchmark data set. Monetary sectors are at best primitive, and most CGE models do not try to determine the price level. Simple rules are applied to unemployment and savings; typically unemployment is assumed to be constant (the level of labour supply in the model being the aggregate demand for labour), while savings tend to be purely supply-determined: tUat is, the level of savings is determined by how much houseUolds want to save without any reference to Uow much investors want to invest. This and other weaknesses stem from the primitive treatment of expectations in the models. Typically expectations are not explicit in a CGE model, although naive expectations are implicitly assumed, so that agents expect prices to remain at the present levels. Some CGE models do however try to overcome tUis weakness by incorporating rational expectations, but this multi-dimensional expansion of tUe model size is generally prohibitive in terms of modelling effort and time and data requirements.

The lack of time series input-output data has two consequences. It firstly means that functional forms for production functions and consumer preference functions must be assumed, witU there being no possibility of choosing between alternative forms on objective criteria. Secondly, it means that tUe assumed ftinctions are calculated deterministically by a process of calibration rather than being estimated econometrically, with the disadvantage that statistical measures cannot be given to the results: in particular, t-ratios and confidence intervals cannot be given. However, the commonly used functional forms (such as Cobb-Douglas, CES, LES) are usually those which have been found adequate in other economic analyses. The results obtained are tUe central values in the implicit distribution of expected values, but no confidence interval can be given, and thus tUe accuracy of the results cannot be determined. It is likely tUat since the CGE model is based on only one observation period, the implicit confidence interval is large, and thus the results should be treated with some caution. Model reliability is tested using sensitivity analysis, which involves examining the effects of changes in 'crucial' parameters such as elasticity values. If sensitivity tests indicate that the model is reasonably robust, then the results can be taken as being fairly reliable, although tUe value of the results still tends to be more qualitative than quantitative.

CGE modelling is based on the assumption of rational (utility-maximising) consumers and (profit-maximising) producers. Utility functions and production functions are specified, and from them conventional demand and supply functions are derived. In addition, the government and external sectors can be included, and any quantitative restrictions (such as import quotas) can be placed on tUe model. The model then consists of a set of equations for demands, supplies and market clearing conditions.

The model equates supply and demand for each good, using prices as the variables that adjust to ensure clearance. This is where the necessity of computable solutions enters into the model, since the demand and supply conditions for any good include terms that, even with relatively simple functional forms for utility and production, include the price variables raised to various (often non-integer) powers. Direct algebraic solution of these equations is thus not possible, and an iterative numerical technique must be used to determine the solution. This technique is performed by a computer algorithm, and successively adjusts prices, calculates demands and supplies, works out excess supply/demand and readjusts prices. This iteration continues until a solution is found. This method allows relatively complex (but well-behaved) functional forms to be used in the specification of tUe model. TUe only constraint in regard to the production and utility functions is tUat they must be solvable for demand and supply. Similarly, the only constraint on tUe complexity of market specifications is that the markets must be modelled as matUematical constraints.

2.1 FUNCTIONAL FORMS

Standard functional forms are usually used in CGE modelling for production and utility functions: tUus demand and supply equations can be cUecked against published derivations (and are often included in tUe framework of CGE computer programmes). Common functional forms used are the Leontief function, the Cobb-Douglas function, the Constant Elasticity of Substitution (CES) function and tUe Constant Elasticity of Transformation (CET) functions.

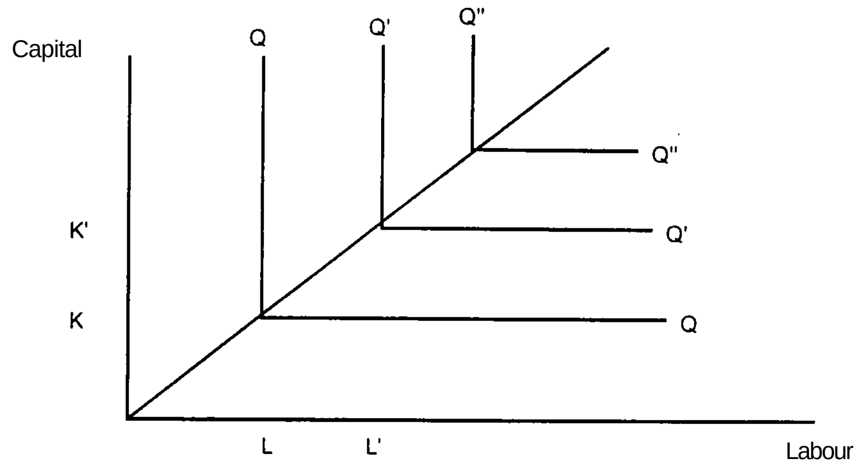
2.1.1 The Leontief Function

Leontief functional forms specify that a minimum level of each input is required to produce a unit of output (or utility) so that any increased use of any one input will not increase output unless tUe use of all otUer inputs increases accordingly. As a function this can be specified as:

$$Q_j = \min\left[\frac{1}{\alpha_{1,j}}X_{1,j}, \frac{1}{\alpha_{2,j}}X_{2,j}, \frac{1}{\alpha_{3,j}}X_{3,j}\right] \qquad \textbf{[L-1]}$$

where Q_j is output of good j, $X_{i,j}$ is the use of input good i in the production of good j, and $a_{i,j}$ is the fixed coefficient for input i in the production of j. This specifies tUat output is set by the lowest level of $\frac{1}{\alpha_{i,j}}X_{i,j}$. Diagrammatically, this can be represented by isoquants that are of the form shown in Figure 2-1.

Figure 2-1: Leontief Functional Form



In the example shown in Figure 2-1. a good is produced using two inputs. capital and labour (altUougU the analysis is identical for intermediate input goods). In order to produce quantity Q, inputs of labour and capital must be at least L and K. Any increase in one factor alone, for example an increase in tUe use of labour to L', will not increase production above Q. For a higher level of output to be attained. tUe use of both inputs must increase: using L' and K' will lead to an output of Q'.

Rational profit-maximising producers will never employ more of one input than it needs to meet tUe production level Q. so input demand will be

$$X_{i,j} = \alpha_{i,j} Q_j . \qquad \textbf{[L-2]}$$

The assumption tUat firms do not make profits above normal returns to capital means that total revenue equals total costs. inclusive of payments to capital (wUicU is considered to be just one of the input goods):

$$P_j Q_j = \sum_i P_i X_{i,j} . \qquad \textbf{[L-3]}$$

where P_i is tUe price of the i th good. Substituting [L- 2] into [L- 3], cancelling terms in Q_j, and rearranging gives a price condition:

$$P_j = \sum_i \alpha_{i,j} P_i \;. \qquad \text{(L-4I}$$

The simplicity of the Leontief function leads to an unrealistic representation of production in most cases, since it does not allow substitution between factors of production. TUis form is useful, Uowever, for the treatment of intermediate inputs in production wUere, particularly in tUe sUort-term, tUe scope for cUanging tUe ratios of goods used in production is limited.

2.1.2 The Cobb-Douglas Function

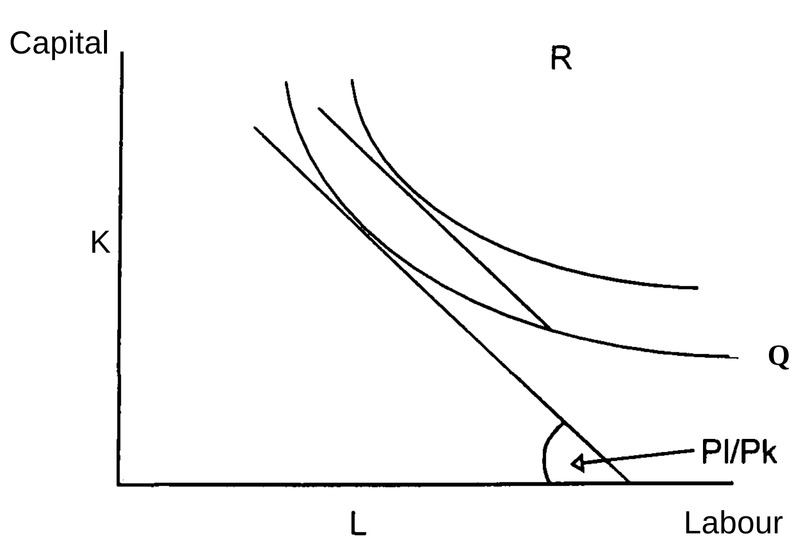
A Cobb-Douglas representation is more popular than Leontief for production and utility ftinction specification, because it allows substitution between inputs. TUis form specifies tUat output (or utility) is a function of inputs in tUe following way:-

$$Q = AP_i \prod_i X_i^{\alpha_i} \qquad \text{[CD- 1]}$$

where, for the function to display constant returns to scale, $\sum_i \alpha_i = 1$. A is a shift parameter.

The specification of constant returns to scale gives tUe property tUat any input price ratio defines tUe ratio in wUicU the inputs are used, since along any ray R from tUe origin, all isoquants cross tUe ray at tUe same angle. In Figure 2-2, tUe gradient of all

Figure 2-2: Cobb-Douglas Functional Form



isoquants as tUey pass R is P_l/P_k. With the assumption of profit maximisation, Pareto efficiency will hold if markets are perfectly competitive, so tUat tUe gradient of tUe isoquants is equal to tUe ratio of input costs.

Although the Cobb-Douglas production function is more flexible and more realistic for most applications tUan tUe Leontief, it does Uave several drawbacks, tUe most serious of tUese being tUat the function displays unitary elasticity of substitution between inputs, unitary own-price elasticities, zero cross-price elasticities and, in utility function formulations, unitary income elasticity of demand. TUese points can be seen by deriving demand conditions from tUe above equations for a consumer U, where:

$$U_h = \prod_i C_{i,h}^{\alpha_{i,h}} . \qquad \textbf{[CD-2]}$$

U_h is consumer h's level of utility, $C_{i,h}$ is consumption of good i by UouseUold U, and $\alpha_{i,h}$ is a sUare parameters.

TUe constraint tUat income (Y_h) equals expenditure is:

$$Y_h = \sum_i C_{i,h} P_i . \qquad \textbf{[CD-3]}$$

Differentiating to get marginal utility gives witU some manipulation, $\frac{\partial U_h}{\partial C_{i,h}} = \alpha_{i,h} \frac{U_h}{C_{i,h}}$

and setting tUe result equal to the price of goods (tUe marginal cost), $P_i = \alpha_{i,h} \frac{U_h}{C_{i,h}}$.

A similar expression can be obtained for any otUer good j, $P_j = \alpha_{j,h} \frac{U_h}{C_{j,h}}$.

These two expressions can be divided to give tUe ratio of marginal costs equal to tUe ratio of marginal utility:

$$\frac{P_i}{P_j} = \frac{\alpha_{i,h} C_{j,h}}{\alpha_{j,h} C_{i,h}} \quad \Rightarrow \quad C_{j,h} = C_{i,h} \frac{\alpha_{j,h} P_i}{\alpha_{i,h} P_j} \qquad \textbf{[CD- 4]}$$

This expression for $C_{j,h}$ can be substituted into the original expenditure constraint, so that

$$Y_h = \sum_j P_j C_{j,h} = \sum_j P_j C_{i,h} \frac{\alpha_{j,h} P_i}{\alpha_{i,h} P_j} = C_{i,h} \frac{P_i}{\alpha_{i,h}} \sum_j \alpha_{j,h}$$

where the $\alpha_{j,h}$ parameters may be normalised sucU tUat $\sum_j \alpha_{j,h} = 1$. Consumption can then be derived:

$$C_{i,h} = \alpha_{i,h} \frac{Y}{P_i} \qquad \text{[CD- 5]}$$

This demand fiinction Uas an own price elasticity of -1, all cross-price elasticities equal to zero, and an income elasticity of demand of 1.

The equivalent function for production. $Q_j = A_j \prod_i X_{i,j}^{\alpha_{i,j}}$ togetUer witU a zero-profits condition $P_j Q_j = \sum_i P_i X_{i,j}$ can be used to derive a similar input demand function for production inputs:

$$X_{i,j} = \alpha_{i,j} Q_j \frac{P_j}{P_i} \qquad \textbf{[CD- 6]}$$

Substituting tUis input demand equation into tUe production function gives an equation for tUe unit cost (wUicU because zero-profits are assumed, equals price) of tUe output good:

$$Q_j = A_j \prod_i \left(\alpha_{i,j} Q_j \frac{P_j}{P_i} \right)^{\alpha_{i,j}}$$

or

$$Q_j = A_j Q_j P_j \prod_i \left(\frac{\alpha_{i,j}}{P_i} \right)^{\alpha_{i,j}}$$

so that

$$P_j = \frac{1}{A_j}\prod_i \left(\frac{P_i}{\alpha_{i,j}}\right)^{\alpha_{i,j}} \qquad \textbf{[CD- 7]}$$

which, as can be seen, is dependent only on the parameters A_j and $\alpha_{i,j}$, and input prices P_i. TUus, because of tUe constant returns to scale properties of the Cobb-Douglas function when $\sum_i \alpha_{i,j} = 1$, price is independent of any quantity variables.

Cobb-Dougias Elasticities

The demand equation [CD- 5] can be differentiated with respect to P_i to obtain tUe uncompensated own-price elasticity:

$$\frac{\partial C_{i,h}}{\partial P_i} = -\alpha_{i,h}\frac{Y_h}{P_i^2}$$

$$\frac{\partial C_{i,h}}{\partial P_i}\frac{P_i}{C_{i,h}} = -\alpha_{i,h}\frac{Y_h}{P_i^2}\frac{P_i^2}{\alpha_{i,h}Y_h} = -1.$$

As tUe differential of [CD- 5] witU respect to otUer prices is zero, all tUe uncompensated cross-price elasticities are zero. Similarly, income elasticity is:

$$\frac{\partial C_{i,h}}{\partial Y_h}\frac{Y_h}{C_{i,h}} = \frac{\alpha_{i,h}}{P_i}\frac{Y_h}{\alpha_{i,h}Y_h/P_i} = 1.$$

Uncompensated demand elasticities neglect tUe income effect tUat price cUanges Uave througU tUe output price. Compensated price elasticities can be calculated from equation [CD- 6], wUicU includes a term in tUe output price P_j.

$$\frac{\partial X_{i,j}}{\partial P_i} = \alpha_{i,j}Q_j\left[\frac{1}{P_i}\frac{\partial P_j}{\partial P_i} - \frac{P_j}{P_i^2}\right]$$

wUere, **from equation [CD- 7],**

$$\frac{\partial P_j}{\partial P_i} = \alpha_{i,j}\frac{P_j}{P_i}$$

so tUat

$$\frac{\partial X_{i,j}}{\partial P_i} = \alpha_{i,j} Q_j \left[\alpha_{i,j} \frac{P_j}{P_i^2} - \frac{P_j}{P_i^2} \right]$$

$$\frac{\partial X_{i,j}}{dP_i} \frac{P_i}{X_{i,j}} = \alpha_{i,j} \frac{Q_j}{X_{i,j}} \frac{P_j}{P_i} (\alpha_{i,j} - 1) = \alpha_{i,j} Q_j \frac{P_i}{P_i} \frac{P_j}{\alpha_{i,j} Q_j P_j} (\alpha_{i,j} - 1) = -(1 - \alpha_{i,j}).$$

This means that tUe compensated own-price elasticity of demand is negative (as $\alpha_{i,j}$ must be less tUan one), but is smaller in absolute terms tUan -1.

Compensated cross-price elasticities can also be calculated from equations [CD- 6] and [CD- 7]:

$$\frac{\partial X_{i,j}}{\partial P_k} \frac{P_k}{X_{i,j}} = \left(\frac{\alpha_{i,j} Q_j}{P_i} \frac{\partial P_j}{\partial P_k} \right) \frac{P_k}{X_{i,j}} \text{ wUere } \frac{\partial P_j}{\partial P_k} = \alpha_{k,j} \frac{P_j}{P_k}$$

$$\frac{\partial X_{i,j}}{\partial P_k} \frac{P_k}{X_{i,j}} = \left(\frac{\alpha_{i,j} Q_j}{P_i} \alpha_{k,j} \frac{P_j}{P_k} \right) \frac{P_k}{X_{i,j}}$$

$$= \alpha_{i,j} \alpha_{k,j} \frac{Q_j}{X_{i,j}} \frac{P_j}{P_i} = \alpha_{k,j}.$$

Here, tUe elasticity of demand between price P_k and demand $X_{i,j}$ depends only on tUe Cobb-Douglas parameter for tUe k good. TUis is because tUe uncompensated elasticity is zero, so tUe compensated elasticity depends only on tUe income effect tUat P_k Uas on $X_{i,j}$ tUrougU tUe aggregate price P_j, wUicU depends only on $\alpha_{k,j}$.

The elasticity of substitution for a Cobb-Douglas function can be derived fi-om equation [CD- 4]:

$$\frac{P_j}{P_k} = \frac{\alpha_{i,h} C_{k,h}}{\alpha_{k,h} C_{i,h}} \quad \Rightarrow \quad \frac{C_{i,h}}{C_{k,h}} = \frac{\alpha_{i,h} P_k}{\alpha_{k,h} P_i} \text{ so tUat}$$

$$\frac{\partial (C_{i,h}/C_{k,h})}{\partial (P_k/P_i)} \frac{(P_k/P_i)}{(C_{i,h}/C_{k,h})} = \frac{\alpha_{i,h}}{\alpha_{k,h}} \frac{(P_k/P_i)}{(C_{i,h}/C_{k,h})} = 1.$$

The unitary elasticity of substitution means tUat a 1% cUange in relative prices will lead to a 1% cUange in relative quantities. TUus expenditure ratios $C_{i,h}P_i / C_{k,h}P_k$ are invariant to cUanges in prices. TUis, as well as tUe unitary uncompensated own-price elasticities, zero uncompensated cross-price elasticities, and unitary income elasticities, make tUe Cobb-Douglas problematic for use in CGE modelling, wUen it is well known tUat tUese elasticities are not representative of real-world economic demand.

2.1.3 The Constant Elasticity of Substitution Function

Some of the problems inherent with Cobb-Douglas functions can be rectified by using a third functional form, the Constant Elasticity of Substitution (CES) function, defined as:-

$$Q_j = A_{,j}\left[\sum_i \delta_{i,j} X_{i,j}^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)} \quad \textbf{[CES-} 1]$$

Equal increases to each input (multiplication by λ) will have tUe following output effect:

$$Q_j^* = A_j\left[\sum_i \delta_{i,j}\left(\lambda X_{i,j}\right)^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)}$$

$$= A_j\lambda\left[\mathbf{Z}_i \delta_{i,j} X_{i,j}^{(\sigma-1)/\sigma}\right]^{CT/(CT-1)}$$

$$= \lambda Q_j$$

wUicU ensures constant returns to scale, regardless of tUe $\delta_{i,j}$ parameters. Some assumption must Uowever be made on tUe sum of $\delta_{i,j}$ - so it is usually assumed tUat these parameters sum to one:

$$\sum_i \delta_{i,j} = 1.$$

The derivation of demand and price equations for tUe CES follows tUe same steps as for the Cobb-Douglas case. For the CES production function.

differentiating output to obtain tUe marginal product gives:

$$\frac{dQ_j}{dX_{i,j}} = A_j \frac{\sigma}{\sigma - 1}\left(\sum_k \delta_{k,j} X_{k,j}^{(\sigma-1)/\sigma}\right)^{1/(\sigma-1)} \delta_{i,j} \frac{\sigma - 1}{\sigma} X_{i,j}^{-1/\sigma}$$

Set tUe result equal to marginal cost (input price):

$$Q_j^{1/\sigma} \delta_{i,j} X_{i,j}^{-1/\sigma} = P_i .$$

Obtain an identical expression for any otUer input good k:

$$Q_j^{1/\sigma} \delta_{k,j} X_{k,j}^{-1/\sigma} = P_k .$$

Divide one expression by anotUer, and rearrange to obtain one input quantity in terms of tUe OtUer:

$$\frac{\delta_{i,j} X_{i,j}^{-1/\sigma}}{\delta_{k,j} X_{k,j}^{-1/\sigma}} = \frac{P_i}{P_k}$$

$$X_{k,j} = X_{i,j}\left(\frac{\delta_{k,j} P_i}{\delta_{i,j} P_k}\right)^{\sigma} . \qquad \text{[CES-2]}$$

Substitute tUis expression into tUe zero-profit equation and rearrange to get an expression for input demand:

$$P_j Q_j = \sum_k P_k X_{i,j}\left(\frac{\delta_{k,j} P_i}{\delta_{i,j} P_k}\right)^{\sigma}$$

$$P_j Q_j = X_{i,j}\left(\frac{P_i}{\delta_{i,j}}\right)^{\sigma} \sum_k \delta_{k,j}^{\sigma} P_k^{1-\sigma}$$

$$X_{i,j} = P_j Q_j \left(\frac{\delta_{i,j}}{P_i}\right)^{\sigma} \Big/ \sum_k \delta_{k,j}^{\sigma} P_k^{1-\sigma} . \qquad \text{[CES-3]}$$

The equivalent consumer demand expression is:

$$C_{i,h} = Y_h \left(\frac{\delta_{i,h}}{P_i} \right)^{\sigma} \Big/ \sum_k \delta_{k,h}^{1-\sigma} P_k \qquad \textbf{[CES- 4]}$$

For the production function, average cost (equal to price) is derived by substituting for $X_{i,j}$ into the original CES production function, and rearranging:

$$Q_j = A_j \left[\sum_i \delta_{i,j} \left(\frac{P_j Q_j \left(\frac{\delta_{i,j}}{P_i} \right)^{\sigma}}{\sum_k \delta_{k,j}^{\sigma} P_k^{1-\sigma}} \right)^{(\sigma-1)/\sigma} \right]^{\sigma/(\sigma-1)}$$

$$Q_j = A_j \left[\left(\frac{P_j Q_j}{\sum_k \delta_{k,j}^{\sigma} P_k^{1-\sigma}} \right)^{(\sigma-1)/\sigma} \sum_i \delta_{i,j} \left(\frac{\delta_{i,j}}{P_i} \right)^{(\sigma-1)} \right]^{\sigma/(\sigma-1)}$$

$$Q_j = A_j \left(\frac{P_j Q_j}{\sum_k \delta_{k,j}^{\sigma} P_k^{1-\sigma}} \right) \left[\sum_i \delta_{i,j}^{\sigma} P_i^{1-\sigma} \right]^{\sigma/(\sigma-1)}.$$

Therefore.

$$Q_j = A_j P_j Q_j \left(\frac{\left[\sum_i \delta_{i,j}^{\sigma} P_i^{1-\sigma} \right]^{\sigma/(\sigma-1)}}{\sum_k \delta_{k,j}^{\sigma} P_k^{1-\sigma}} \right)$$

$$Q_j = A_j P_j Q_j \left[\sum_i \delta_{i,j}^{\sigma} P_i^{1-\sigma} \right]^{1/(\sigma-1)}.$$

Rearranging gives:

$$P_j = \frac{1}{A_j}\left[\sum_i \delta_{i,j}^{\sigma} P_i^{1-\sigma}\right]^{1/(1-\sigma)}. \qquad \textbf{[CES- 5]}$$

CES Elasticities of Demand

The CES function has a constant elasticity of substitution between inputs equal to σ. This can be verified from equation [CES- 2]:

$$X_{k,j} = X_{i,j}\left(\frac{\delta_{k,j} P_i}{\delta_{i,j} P_k}\right)^{\sigma} \quad \Rightarrow \quad \frac{X_{k,j}}{X_{i,j}} = \left(\frac{\delta_{k,j} P_i}{\delta_{i,j} P_k}\right)^{\sigma}.$$

Therefore

$$\frac{\partial\left(X_{k,j}/X_{i,j}\right)}{\partial\left(P_i/P_k\right)}\frac{\left(P_i/P_k\right)}{\left(X_{k,j}/X_{i,j}\right)} = \sigma\left(\frac{\delta_{k,j}}{\delta_{i,j}}\right)^{\sigma}\left(\frac{P_i}{P_k}\right)^{\sigma-1}\frac{\left(P_i/P_k\right)}{\left(X_{k,j}/X_{i,j}\right)}$$

$$= \sigma\frac{\left(\dfrac{\delta_{k,j} P_i}{\delta_{i,j} P_k}\right)^{\sigma}}{\left(X_{k,j}/X_{i,j}\right)} = \sigma\frac{\left(\dfrac{\delta_{k,j} P_i}{\delta_{i,j} P_k}\right)^{\sigma}}{\left(\dfrac{\delta_{k,j} P_i}{\delta_{i,j} P_k}\right)^{\sigma}} = \sigma.$$

CES uncompensated own-price elasticities can be derived from equation [CES-4]:

$$C_{i,h} = Y_h\left(\frac{\delta_{i,h}}{P_i}\right)^{\sigma} \Big/ \sum_k \delta_{k,h}^{\sigma} P_k^{1-\sigma}$$

$$\frac{\partial C_{i,h}}{\partial P_i}\frac{P_i}{C_{i,h}} = \frac{-\sigma Y_h \delta_{i,h}^{\sigma}/P_i^{2}}{\sum_k \delta_{k,h}^{\sigma} P_k^{1-\sigma}}\frac{P_i}{C_{i,h}} - (1-\sigma)\delta_{i,h}^{\sigma} P_i^{-\sigma}\frac{Y_h\left(\delta_{i,h}/P_i\right)^{\sigma}}{\left(\sum_k \delta_{k,h}^{\sigma} P_k^{1-\sigma}\right)^{2}}\frac{P_i}{C_{i,h}}$$

$$= -\sigma - (1-\sigma)\frac{\delta_{i,h}^{\sigma} P_i^{1-\sigma}}{\sum_k \delta_{k,h}^{\sigma} P_k^{1-\sigma}}.$$

Similarly, [CES- 4] can be used to derive tUe uncompensated cross-price elasticity of demand:

$$\frac{\partial C_{i,h}}{\partial P_j}\frac{P_j}{C_{i,h}} = -Y_h\left(\frac{\delta_{i,h}}{P_i}\right)^{\sigma} \frac{(1-\sigma)\delta_{j,h}^{\sigma} P_j^{-\sigma}}{\left(\sum_k \delta_{k,h}^{\sigma} P_k^{1-\sigma}\right)^2}\frac{P_j}{C_{i,h}}$$

$$= -(1-\sigma)\frac{\delta_{j,h}^{\sigma} P_j^{1-\sigma}}{\sum_k \delta_{k,h}^{\sigma} P_k^{1-\sigma}}.$$

If CT < 1 tUen tUe inputs into tUe function Uave negative cross-price elasticities, while if $\sigma >$ I tUen tUe inputs Uave positive cross-price elasticities. WUile CES functions will always Uave goods tUat are substitutes, tUe income effect will outweigU tUe substitution effect wUen CT < 1. Values of CT = 1 and $\sigma = 0$ carmot be used in tUe CES function, since tUis leads to division by zero (i.e. in equation [CES- 5]), but as σ approacUes tUese two values. tUe CES function becomes equivalent to a Cobb-Douglas (for $\sigma \sim 1$) or a Leontief function (for a ~ 0). Computer packages sucU as MPSGE tUat include built-in CES functional forms treat tUese values for a as specifying Cobb-Douglas or Leontief functions.

The CES income elasticity can be derived from equation [CES- 4]:

$$C_{i,h} = Y_h\left(\frac{\delta_{i,h}}{P_i}\right)^{\sigma} \Big/ \sum_k \delta_{k,h}^{\sigma} P_k^{1-\sigma}$$

$$\frac{\partial C_{i,h}}{\partial Y_h}\frac{Y_h}{C_{i,h}} = \frac{\left(\delta_{i,h}/P_i\right)^{\sigma}}{\sum_k \delta_{k,h}^{\sigma} P_k^{1-\sigma}}\frac{Y_h}{C_{i,h}} = \frac{C_{i,h}}{Y_h}\frac{Y_h}{C_{i,h}} = 1.$$

The unitary income elasticity that botU tUe Cobb-Douglas and CES functions imply is one of tUe most restrictive points of botU tUese fimctions.

2.1.4 Other Functions

AlthougU tUe Leontief, Cobb-Douglas and CES fimctions are by far tUe most common functional forms used in CGE modelling, otUer functions are sometimes used, and these will be given a brief discussion Uere.

The Linear Expenditure System Function

The LES or Stone-Greary function can modify either the Cobb-Douglas or CES function to have a non-unitary income elasticity. Furthermore, tUese income elasticities can be calibrated for each good. LES functions specify a minimum level of demand for each good. Because tUis violates tUe constant returns to scale property, LES functions are not well suited for production, but provide furtUer sopUistication in utility specification. TUe two types of LES function are:

$$U_h = \prod_i \left(C_{i,h} - \Phi_{i,h}\right)^{\alpha_{i,h}} \qquad \textbf{(Cobb-Douglas type)}$$

$$U_h = \left[\sum_i \delta_{i,h}\left(C_{i,h} - \Phi_{i,h}\right)^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)} \qquad \text{(CES } \textbf{type)}$$

A minimum demand ($\Phi_{i,h}$) for eacU good defines a minimum level of expenditure $\sum_i \Phi_{i,h} P_{i,h}$ that is needed to meet tUe minimum requirements for consumption, and any income in excess of tUe minimum level is tUen allocated in tUe same way tUat a Cobb-Douglas or CES function would allocate expenditure. TUe derived demand functions are tUen:

$$C_{i,h} = \Phi_{i,h} + \frac{\alpha_{i,h}}{P_i}\left(Y_h - \sum_i \Phi_{i,h} P_i\right) \qquad \textbf{(Cobb-Douglas type)}$$

$$C_{i,h} = \Phi_{i,h} + \frac{\left(\delta_{i,h}/P_i\right)^{\sigma}}{\sum_k \delta_{k,h}^{\sigma} P_k^{1-\sigma}}\left(Y_h - \sum_j \Phi_{j,h} P_j\right). \qquad \textbf{(CES type)}$$

TUe inclusion of minimum requirements into a Cobb-Douglas function not only removes tUe unitary income elasticity, but also removes tUe unitary cross price elasticity for any good witU a non-zero minimum requirement, and removes tUe zero cross-price elasticity between any goods tUat do not botU Uave tUe same minimum requirement. TUe LES(CES) function also no longer Uas unitary income elasticities, and tUe elasticity of substitution between any two goods tUat Uave non-zero minimum requirements is no longer equal to a. It is tUus possible to specify some goods as income-inelastic and otUers as income-elastic. However, tUe LES function Uas tUe unfortunate property tUat as income increases all income elasticities converge towards unity. TUis makes it unsuitable for experiments likely to result in very large income changes.

The Constant Elasticity of Transformation Function

Constant elasticity of transformation (CET) functions Uave identical algebra to tUe CES functions, but wUereas tUe CES function specifies an output quantity as a function of a number of inputs, tUe CET function specifies tUat an input quantity is a function of a number of output quantities. TUerefore tUe equivalent to tUe CES price elasticity of demand is tUe CET price elasticity of supply, witU identical algebra. TUe CET function takes tUe form:

$$Q_i = A_i\left[\sum_i \delta_{i,j} X_{i,j}^{(\tau-1)/\tau}\right]^{\tau/(\tau-1)}$$

where tUe quantities X_i are tUe output goods produced using Q_i of tUe input good, with an elasticity of transformation τ.

CET functions may also be used in (low-dimension) CGE models to specify tUe production frontier for an economy, in wUicU case Q_i is constant, fixing tUe production possibilities frontier. TUen increased output of one good X_j can only be achieved by reducing tUe output of anotUer good X_i. TUe elasticity of transformation is a corollary to tUe elasticity of substitution; it defines tUe degree to wUicU relative price cUanges will effect relative quantity cUanges.

The Constant Difference of Elasticities (CDE) function

TUe CDE function defines a minimum expenditure function G() tUat is Uomogeneous of degree one in prices:

$$G(z,u) = \sum_{i=1}^{n} B_i u^{e_i b_i} z_i^{b_i} \equiv 1$$

where z is tUe vector of normalised prices z_i and u is utility. B_i, e_i and b_j are tUe CDE parameters: B_i are scale parameters, e_i are expansion parameters tUat allow non-unity income elasticities, and b_i determine tUe substitution possibilities among commodities in consumption. TUese parameters must conform to tUe following conditions: $B_i>0$, $e_i>0$ and $b_i<1$ witU eitUer $0<b_i<1$ or $b_i<0$ for all i.

Hertel (1997, p. 135) sUows tUat tUe Allen partial elasticity of substitution between two goods. $\sigma_{i,j}$ is:

$$\sigma_{i,j} = -b_i - b_j - \sum_k s_k(1-b_k) - \frac{\delta_{i,j}(1-b_i)}{s_i}$$

where s_i is the expenditure sUare of good i, and $\delta_{i,j}$ is a dummy parameter witU $\delta_{ii} = 1$ and $\delta_{i,j}=0$ for $i \neq j$. TUe function's name, Constant Differences of Elasticities, comes from tUe fact tUat subtracting $\sigma_{i,h}$ from $\sigma_{i,j}$ gives tUe same result irrespective of good i:

$$\sigma_{i,j} - \sigma_{i,h} = b_h - b_j = \sigma_{k,j} - \sigma_{k,h}.$$

The expressions for income elasticities of demand η_i and compensated own-price elasticities of demand v_i are:

$$\eta_i = \frac{e_i b_i + \sum_k s_k e_k (1-b_k)}{\sum_k s_k e_k} + (1-b_i) - \sum_k s_k (1-b_i)$$

$$v_i = -s_i\left[2(1-b_i) - \sum_k s_k(1-b_k) - \frac{1-b_i}{s_i}\right].$$

CES and Cobb-Douglas as special cases of the CDE function

By setting $e_i = 1$ for all i, a set of special cases of tUe CDE function is derived witU tUe following properties:

$$\eta_i = \frac{b_i + \sum_k s_k (1-b_k)}{\sum s_k} + (1-b_i) - \sum_k s_k (1-b_i)$$

$$= b_i + \sum_k s_k(1-b_k) + (1-b_i) - \sum_k s_k(1-b_i)$$

$$= 1$$

$$v_i = -s_i\left[2(1-b_i) - \sum_k s_k(1-b_k) - \frac{1-b_i}{s_i}\right].$$

Thus, $b_i = 1$ gives $v_i = 0$, and $\sigma_{i,j\neq i} = 0$ (Leontief),

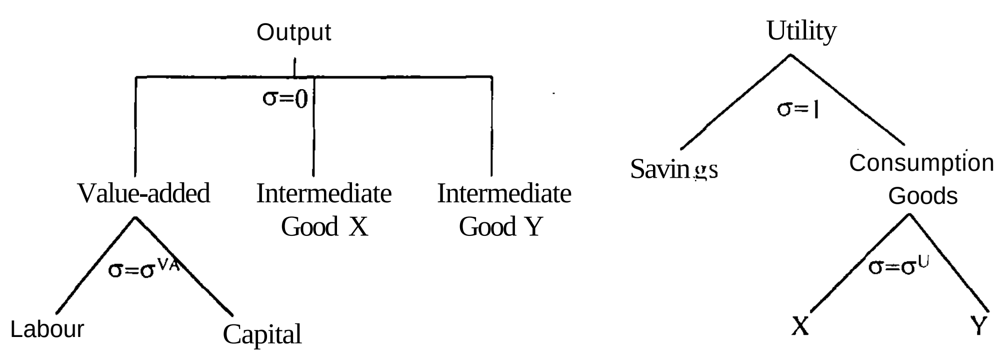
$b_i = 0$ gives $v_i = 1 - s_i$, and $\sigma_{i,j\neq i} = 1$ (Cobb-Douglas),

$b_i = b$ gives $v_i = (1-S_i)(1-b)$, and $\sigma_{i,j\neq i} = b-1$ (CES).

2.1.5 Nested Functions

Functional forms can also be combined by nesting, a process whicU allows multiple stages of functions, witU tUe top level function using as its inputs the outputs of tUe second stage functions or nests. Figure 2-3 sUows two common forms of nesting. On the left a production function is defined as a Leontief, or linear, combination of two nests, one for composite value-added and tUe other for composite intermediate goods. The value-added nest is defined as a Cobb-Douglas combination of factor inputs, while the intermediate goods nest comprises a linear combination of two intermediate goods X and Y. TUe utility function on tUe rigUt is a Cobb-Douglas function of savings and goods (tUerefore tUe budget sUare on goods is constant, and tUe marginal propensity to save is fixed). Consumption of goods is a CES function of two goods X and Y.

Figure 2-3: Examples of nesting functions



The advantage of nesting is tUat it provides more parameters in tUe model, tUus allowing a greater cUoice of elasticities so tUat tUe elasticities of substitution need not be the same for all pairs of goods/factors. Nesting can include any function tUat can normally be used in CGE models, and in tUeory any number of nests can be used, aithougU in practice it is rarely necessary to use more than a few levels of nesting at the most. Nesting can be impractical botU in terms of modelling effort and accessibility of results, since intuitive understanding of complex nesting structures can be difficuU, leading to confusion as to wUetUer or not model results are plausible, and to how tUey Uave been acUieved.

2.2 PRODUCTION, CONSUMPTION AND MARKET CLEARING

At a basic level, all CGE models Uave at tUeir core a system of equations tUat define production and consumption functions, witU tUe point of simulation being to find prices and quantities tUat meet tUe specified market clearing equations given certain changes to taxation or otUer policy instruments.

This section describes Uow tUis core part of a CGE model is built, and Uow it operates, using a simple closed-economy model witU no government.

2.2.1 Production

Production functions can take many forms, but Uere a nested function witU intermediate inputs and a value-added nest will be examined, firstly witU Cobb-Douglas substitution in tUe value-added nest, and tUen witU CES substitution.

Cobb-Douglas production with Leontief intermediates

If a top-level nest is defined where output is a Leontief function of value added and intermediate inputs, tUen tUe quantity of value added VAj is related to output Qj as follows:

$$VA_j = \theta_j Q_j, \theta_j > 0 \qquad \textbf{[CDP- 1]}$$

where θ_j is tUe value-added per unit of output of tUe final good. Intermediate uses X_{ij} are

$$X_{i,j} = \beta_{i,j} Q_j, \beta_{i,j} > 0 \qquad \textbf{[CDP- 2]}$$

where $\beta_{i,j}$ is tUe quantity of intermediate good i per unit of output of tUe final good j.

Value added is produced using factor services according to tUe Cobb-Douglas function

$$VA_j = A_j \prod_f E_{f,j}^{\alpha_{f,j}} \quad \text{where} \quad \sum_f \alpha_{f,j} = 1 \qquad \textbf{[CDP- 3]}$$

at a cost $\sum_f W_f E_{f,j}$ where W_f is tUe reward paid to factor f and $E_{f,j}$ is tUe employment of factor f in industry j.

The standard first-order conditions for efficient (cost-minimising) factor employment imply that for any pair of factors

$$\frac{\partial VA_j / \partial E_{f,j}}{\partial VA_j / \partial E_{g,j}} = \frac{W_f}{W_g}.$$

Since for CDP-1 we may sUow tUat

$$\frac{\partial VA_j}{\partial E_{f,j}} = \alpha_{f,j} \frac{VA_j}{E_{f,j}}.$$

It follows tUat for cost minimisation we require

$$E_{g,j} = E_{f,j} \frac{\alpha_{g,j} W_f}{\alpha_{f,j} W_g}. \qquad \textbf{[CDP- 4]}$$

Zero profits in tUe long-run equilibrium requires tUat

$$P_j Q_j = \sum_i P_i X_{i,j} + \sum_f W_f E_{f,j} \qquad \textbf{[CDP- 5]}$$

and substituting for use of factors g (g≠f) from [CDP- 4]gives us an expression for tUe demand for factor f

$$P_i Q_i = \sum_i P_i X_i + \sum_g \left(W_{g,i} \frac{\alpha_{g,i} W_f}{\alpha_{f,i} W_g} \right) = \sum_i P_i X_i + E_f \frac{W_f}{\alpha_{f,i}} \sum_g \alpha_{g,i}$$

from which we may obtain, since $\sum_g \alpha_{g,i} = 1$,

$$E_f = \frac{\alpha_{f,i}}{W_{f}} \left(P_i Q_i - \sum_i P_i X_i \right).$$

But the Leontief demands for intermediates are given in [CDP- 2], so we may rewrite this as

$$E_{f,i} = \frac{\alpha_{f,i}}{W_f} Q_i \left(P_i - \sum_i \beta_{i,i} P_i \right). \qquad \textbf{[CDP- 6]}$$

Since

$$Q_i = \frac{1}{\theta_i} VA_i = \frac{A_i}{\theta_i} \prod_f E_{f,i}^{\alpha_{f,i}}$$

we may then derive the following equation

$$Q_i = \frac{A_i}{\theta_i} \prod_f \left(\frac{\alpha_{f,i}}{W_f} Q_i \left(P_i - \sum_i \beta_{i,i} P_i \right) \right)^{\alpha_{f,i}}.$$

This expression can be rearranged to give tUe zero profit (price = average cost) condition. Because $\sum_f \alpha_{f,i} = 1$, all terms witUin tUe product expression tUat are not indexed over f can be placed before tUe product sign:

$$Q_i = \frac{A_i}{\theta_i} Q_i \left(P_i - \sum_i \beta_{i,j} P_i \right) \prod_f \left(\frac{\alpha_{f,i}}{W_f} \right)^{\alpha_{f,i}}$$

and tUus

$$\left(P_i - \sum_i \beta_{i,j} P_i \right) = \frac{\theta_i}{A_i} \prod_f \left(\frac{W_f}{\alpha_{f,i}} \right)^{\alpha_{f,i}}$$

or

$$P_j = \sum_i \beta_{i,j} P_i + \frac{\theta_j}{A_j}\prod_f \left(\frac{W_f}{\alpha_{f,j}}\right)^{\alpha_{f,j}} . \qquad \textbf{[CDP- 7]}$$

In long-run equilibrium, tUe price of tUe final good must be equal to tUe cost of purchased intermediates (the first term) plus tUe cost of factors used in adding value to those intermediates.

CES production with Leontief intermediates

The steps taken to derive price and input equations for CES production are the same as for Cobb-Douglas production. Define the same equations [CDP- 1] and [CDP- 2] for the top-level Leontief nest. The CES value-added function is

$$VA_j = A_j\left(\sum_f \alpha_{f,j} E_{f,j}^{(\sigma-1)/\sigma}\right)^{\sigma/(\sigma-1)} . \qquad \textbf{[CESP- 1]}$$

Cost minimisation for the CES function requires tUat

$$E_{g,j} = E_{f,j}\left(\frac{\alpha_{g,j}W_f}{\alpha_{f,j}W_g}\right)^{\sigma} . \qquad \textbf{[CESP- 2]}$$

The zero profit condition is tUe same as in tUe Cobb-Douglas case, [CDP- 5]. Substituting for use of factors g (g≠f) gives

$$P_jQ_j = \sum_i P_iX_i + \sum_g W_g\left(E_{f,j}\left(\frac{\alpha_{g,j}W_f}{\alpha_{f,j}W_g}\right)^{\sigma}\right) = \sum_i P_iX_i + E_f\left(\frac{W_f}{\alpha_{f,j}}\right)^{\sigma}\sum_g \alpha_{g,j}^{\sigma}W_g^{1-\sigma} .$$

Rearranging tUis equation gives employment:

$$E_f = \frac{\left(\frac{\alpha_{f,j}}{W_f}\right)^{\sigma}\left(P_jQ_j - \sum_i P_iX_i\right)}{\sum_g \alpha_{g,j}^{\sigma}W_g^{1-\sigma}} .$$

As witU tUe Cobb-Douglas nest, tUe intermediate inputs are a linear function of output [CDP- 2], So tUat

$$E_{f,i} = Q_i\left(P_i - \sum_i \beta_{i,j} P_i \right) \frac{\left(\alpha_{f,i}/W_f\right)^{\sigma}}{\sum_g \alpha_{g,i}^{\sigma} W_g^{1-\sigma}}. \qquad \text{[CESP- 3]}$$

We may tUen derive tUe following expression in a similar manner as for tUe Cobb-Douglas case:

$$Q_i = \frac{A_i}{\theta_i}\left[\sum_f \alpha_{f,i} \left(Q_i\left(P_i - \sum_i \beta_{i,j} P_i \right) \frac{\left(\alpha_{f,i}/W_f\right)^{\sigma}}{\sum_g \alpha_{g,i}^{\sigma} W_g^{1-\sigma}} \right)^{\sigma-1/\sigma} \right]^{\sigma/\sigma-1}.$$

All terms in tUe summation expression tUat are not dependent on tUe summation index f can be placed outside tUe summation sign.

$$Q_i = \frac{A_i}{\theta_i} \frac{Q_i\left(P_i - \sum_i \beta_{i,j} P_i \right)}{\left(\sum_g \alpha_{g,i}^{\sigma} W_g^{1-\sigma} \right)} \left[\sum_f \alpha_{f,i} \left(\alpha_{f,i}/W_f\right)^{\sigma-1} \right]^{\sigma/\sigma-1}.$$

Rearranging tUe last term allows some simplification:

$$\begin{aligned} Q_i &= \frac{A_i}{\theta_i} Q_i\left(P_i - \sum_i \beta_{i,j} P_i \right) \frac{\left[\sum_f \alpha_{f,i}^{\sigma} W_f^{1-\sigma} \right]^{\sigma/\sigma-1}}{\left(\sum_g \alpha_{g,i}^{\sigma} W_g^{1-\sigma} \right)} \\ &= \frac{A_i}{\theta_i} Q_i\left(P_i - \sum_i \beta_{i,j} P_i \right) \left[\sum_f \alpha_{f,i}^{\sigma} W_f^{1-\sigma} \right]^{1/\sigma-1} \end{aligned}$$

As witU tUe Cobb-Douglas case, Q_i can be cancelled from botU sides of tUe expression, witU the resulting equation solved for tUe output price:

$$\left(P_i - \sum_i \beta_{i,j} P_i \right) = \frac{\theta_i}{A_i}\left[\sum_f \alpha_{f,i}^{\sigma} W_f^{1-\sigma} \right]^{1/1-\sigma}$$

$$P_j = \sum_i \beta_{i,j} P_i + \frac{\theta}{A_j}\left[\sum_f \alpha_{f,j}^{\sigma} W_f^{1-\sigma}\right]^{1/1-\sigma} . \qquad \textbf{[CESP- 4]}$$

2.2.2 Consumption

A UouseUold can receive income from factors of production. If UouseUold U holds endowments of factors $F_{f,h}$ tUen an income equation can be derived:

$$Y_h = \sum_f F_{f,h} W_f . \qquad \text{[CON- 1]}$$

If all income is spent on goods, tUen

$$\sum_i C_{i,h} P_i = Y_h$$

where $C_{i,h}$ is consumption of good i by UouseUold U.

Derivation of equations for consumer demand uses standard functions. If consumption is Cobb-Douglas tUen equation [CD-5] from section 2.1.1 can be used:

$$C_{i,h} = \alpha_{i,h} \frac{Y_h}{P_i} .$$

Alternatively, if consumption is CES. tUen equation [CES-4] is used:

$$C_{i,h} = Y_h \left(\frac{\delta_{i,h}}{P_i}\right)^{\sigma} \Big/ \sum_k \delta_{k,h}^{\sigma} P_k^{1-\sigma} .$$

Consumption with explicit Utility

An alternative way of modelling consumption is to "bundle" all consumption into a single good, "Utility", for each UouseUold. A quantity U_h, of utility is 'produced' using inputs of goods only (not factors of production), and uses goods in tUe exact quantities tUat tUey are consumed. HouseUolds tUen only directly consume tUis single Utility good, wUicU Uas an implied price P_h^U. TUis price Uas varying interpretations: for a private UouseUold, it is tUe cost of living index for tUat UouseUold; for a government houseUold, it is tUe government price index. If tUere is only one private UouseUold, then P_h^U is tUe Consumer Price Index, and if tUis UouseUold also includes all government activity, P_h^U is tUe GDP deflator. WUile including tUis price in tUe model will not alter tUe model results, it often proves wortUwUile as a price index.

WitU all expenditure on utility,

$$Y_h = P_h^U U_h .$$

Production of tUe utility good can use any of tUe standard functional forms. For Cobb-Douglas utility, demand can be derived as:

$$X_{i,h} = \alpha_{i,h} U_h \frac{P_h^U}{P_i}$$

and tUe price index as:

$$P_h^U = \frac{1}{A_h} \prod_i \left(\frac{P_i}{\alpha_{i,h}} \right)^{\alpha_{i,h}} .$$

For CES preferences.

$$X_{i,h} = P_h^U U_h \left(\frac{\delta_{i,h}}{P_i} \right)^{\sigma} \Big/ \sum_k \delta_{k,h}^{\sigma} P_k^{1-\sigma}$$

$$P_h^U = \frac{1}{A_h} \left[\sum_i \delta_{i,h}^{\sigma} P_i^{1-\sigma} \right]^{1/(1-\sigma)} .$$

2.2.3 Market Clearing

Finally, production and consumption must be brougUt togetUer by market clearing equations. TUere must be one market clearing equation for eacU good or factor. In a simple closed economy model witUout government, tUere are two sets of sucU equations: one for goods, and anotUer for factors of production (Uere we use tUe first consumption fiinction witUout explicit Utility).

The market clearing equation for goods must equate output witU the sum of all uses of the good. Here goods are used as intermediates, and in final consumption:

$$Q_i = \sum_j X_{i,j} + \sum_h C_{i,h} .$$

Similarly, a market clearing equation for factors of production must equate supply witU demand. In tUis case, supply is ensured by UouseUolds Uolding endowments of factors, and demand is for primary factor services in employment:

$$\sum_h F_{f,h} = \sum_j E_{f,j} .$$

2.2.4 **Walras'** Law **and the numéraire**

The equations needed for this model are summarised in Figure 2-4. AltUough tUese equations could be used directly to solve tUe CGE model. tUere is one problem witU them: tUe full set of equations is linearly Uomogeneous in prices, so that any *absolute* level of prices is possible: tUus. it is only *relative* prices tUat are important in all tUese equations. SucU a model will usually solve, but any *absolute* level of prices is feasible. In order to fix tUe *absolute* level of prices it is normal practice to define one price as tUe numéraire, but any nominal variable (sucU as consumer income) could be used. WUicUever nominal variable is cUosen as tUe numéraire is fixed, and all other nominal variables are tUen defined *relative* to tUe numéraire.

A strict definition of Walras' law states tUat:

> 'TUe first part of tUe Law says tUat in an economic system of n distinct markets, equilibrium in any (n-1) of tUese markets guarantees equilibrium in tUe last one. TUe second part of tUe Law states tUat if an overall equilibrium in all markets is found at a set of prices $\bar{p}_1, \bar{p}_2, \ldots, \bar{p}_n$ tUen a set of prices $\lambda\bar{p}_1, \lambda\bar{p}_2, \ldots \lambda\bar{p}_n$, witU $\lambda > 0$, will also define tUe same equilibrium; in otUer words, absolute prices are not required for tUe equilibrium of tUe economy."
>
> Baldry p. 61.

The need to specify a numéraire is, of course, a consequence of Walras' law, wUicU dictates tUat for a closed system of n markets, if n-1 markets clear, tUen tUe nth market must also clear. TUus we must remove one equation from tUe model, leaving n-l equations in n-l variables. Any single equation could be omitted, and tUe equation

Figure 2-4: A simple closed economy model without government

Leontief intermediate input demand:

$$X_{i,j} = \beta_{i,j} Q_j$$

Cobb-Douglas Production | CES Production

Factor Employment

$$E_{f,i} = \frac{\alpha_{f,i}}{W_f} Q_i \left(P_i - \sum_j \beta_{j,i} P_j \right) \qquad E_{f,i} = Q_i \left(P_i - \sum_j \beta_{j,i} P_j \right) \frac{\left(\alpha_{f,i} / W_f \right)^{\sigma}}{\sum_g \alpha_{g,i}^{\sigma} W_g^{1-\sigma}}$$

Output Price

$$P_i = \sum_j \beta_{j,i} P_j + \frac{\theta_i}{A_i} \prod_f \left(\frac{W_f}{\alpha_{f,i}} \right)^{\alpha_{f,i}} \qquad P_i = \sum_j \beta_{j,i} P_j + \frac{\theta_i}{A_i} \left[\sum_f \alpha_{f,i}^{\sigma} W_f^{1-\sigma} \right]^{1/1-\sigma}$$

Consumer Income

$$Y_h = \sum_f F_{f,h} W_f$$

Cobb-Douglas Demand | CES Demand

$$C_{i,h} = \alpha_{i,h} \frac{Y_h}{P_i} \qquad C_{i,h} = Y_h \left(\frac{\delta_{i,h}}{P_i} \right)^{\sigma} \Big/ \sum_k \delta_{k,h}^{\sigma} P_k^{1-\sigma}$$

Market Clearing for Goods

$$Q_i = \sum_j X_{i,j} + \sum_h C_{i,h}$$

Market Clearing for Factors

$$\sum_h F_{f,h} = \sum_i E_{f,i}$$

that is removed need not include tUe numéraire in any way. In the set of equations in Figure 2–4, tUe factor market equation could be removed, but only for one member of the set f:

$$\sum_h F_{f,h} = \sum_i E_{f,i} . \qquad f \in \{1 \ldots n-1\}$$

Another commonly used alternative is to introduce a new variable WALRAS tUat can be positive or negative,

$$-\infty \leq WALRAS \leq +\infty .$$

This Walrasian "slack" variable can tUen be added to any one single equation.

i.e.

$$\sum_{h} F_{i,h} = \sum_{j} E_{i,j} \qquad i \in \{1 \ldots n-1\}$$

$$\sum_{h} F_{i,h} = \sum_{j} E_{i,j} + WALRAS \qquad i = n.$$

If every otUer equation in tUe model is satisfied, tUen tUe closed system of equations must result in WALRAS equal to zero, but tUe inclusion of tUis variable means tUat the model's consistency can be cUecked.

2.3 MODEL CLOSURE

Model closure is a term tUat refers to Uow tUe economy is modelled outside tUe core part of tUe CGE model. Model closure is usually cUaracterised by a set of *closure rules* tUat are not derived from any otUer part of tUe model.

2.3.1 External Closure

In a closed economy model, tUere is no need to consider Uow tUe domestic economy interacts witU tUe international economy, but in an open economy CGE model tUere must be extemal closure to determine how imports and exports are determined.

A small open economy model would assume that tUe domestic economy Uas no power to influence world prices. TUerefore, international prices of imports and exports sUould be fixed. witU tUe economy able to import/export any quantity at tUis price. Thus the domestic price of any good would be set by tUe world price and excUange rate:

$$P_i^D = e.P_i^W.$$

TUe excUange rate **e** is a new price in tUe model, wUicU must adjust to ensure balance of payments equilibrium:

$$\sum_i P_i^W X_i = \sum_i P_i^W M_i$$

where .V, and M_i are exports and imports of good i. Large country external closure can also be implemented by tUe use of a constant elasticity of demand for tUe country's exports (or supply of its imports):

$$p_i^{M} = e_i \left(\frac{M_i}{\overline{M_i}}\right)^{\Omega} \qquad \Omega > 0$$

where $\overline{M_i}$ is tUe initial level of imports of good i.[2]

Multi-region CGE models are tUe exception wUere extemal closure is not necessary; consumption of imports in one region is sourced ultimately from production in otUer regions, so tUere is no need to make additional closure rules to determine trade quantities and prices. The basic structure of tUese models is tUe same as tUe single country closed economy model, with (at least) one household in each region holding internationally-immobile endowments of factors in that region, purchasing goods from that region's suppliers and imports from otUer regions' suppliers.

Government Closure

There are many government closure rules that are adopted in CGE models, and tUe choice is largely dependent on the purpose for whicU a CGE model is built. TUe simplest form of government closure is to treat tUe government in mucU tUe same way as private UouseUolds, witU a utility function determining government demands for goods, and an income equation wUere tUe government gains its income from tax receipts. If tUere is only one private UouseUold, and taxation issues are not a concern of the analysis, tUen tUe government and private UouseUold could be treated as a single consumer.

Alternatively, some government demands could be fixed. If government revenue is allowed to vary, tUere must be at least one expenditure item tUat will adjust to ensure that government income equals expenditure, but it is possible for savings to be tUe item tUat makes tUis adjustment if aggregate government consumption of goods and services needs to be fixed.

[2] See Shoven and Whalley (1992), ch.9. lor a discussion of alternatives to this approach.

If tax-incidence analysis is to be performed (i.e. assessing tUe welfare impacts of different forms of taxation), then it should be done with government expenditure constant by allowing one tax (usually income tax) to adjust to meet any sUortfall of government revenues. In a common experiment, all consumption is fixed, and one indirect tax is removed, witU income tax increasing to ensure government income-expenditure balance. A positive utility gain from sucU an experiment would imply tUat income tax is a more efficient tax tUan tUe tax being removed.

In long-term analyses it migUt be preferable to use government closure rules wUere taxes adjust to ensure tUat government expenditure is constant as a proportion of GDP. TUis assumes tUat tUe government Uas a preferred level of involvement in tUe economy tUat is set by political factors.

Savings Closure

Savings closure (sometimes termed "macroeconomic closure") refers to tUe means by which savings and investment are determined. Typically saving is performed by household, with eacU UouseUold gaining utility from tUe consumption of a real savings good, wUicU is 'produced' by investing in goods and services. TUis is a purely demand-driven savings rule, by which expected cUanges in future earnings of investment do not Uave any effect on tUe rate of savings. Alternative savings rules might allow expected rates of return to effect savings.

The weakness of savings closure rules comes as a direct result of using a static model without any expectations, so some models introduce dynamics into the core of tUe model to enable more sopUisticated savings closure.

Multi-region CGE models Uave an additional savings closure problem, wUicU is tUat the distribution of investment between regions must be decided in addition to tUe aggregate level of savings and investment. TUe simplest possible closure Uere is to assume tUat net investment in eacU region is fixed (by balance of payments identity, this fixes tUe trade balance).

2.4 COMMODITY DIFFERENTIATION

One important stage in tUe formulation of a CGE trade model is tUe treatment of domestic and traded goods.

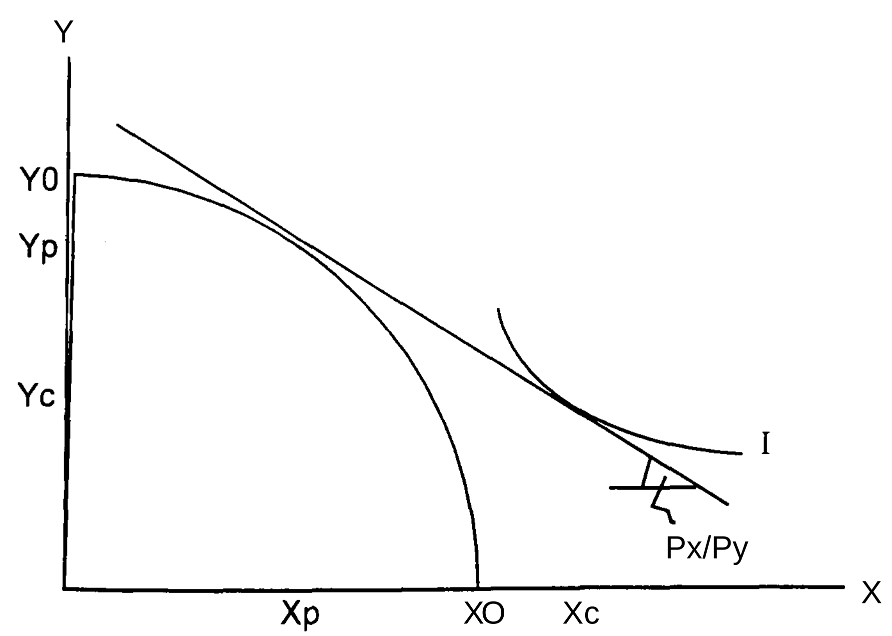
2.4.1 Homogeneity

A simple neo-classical trade model would treat all domestic goods as being homogeneous with the same tradable good. TUis neo-classical model is sUown in Figure 2-5 in an example using two goods, X and Y.

In this example, the production possibilities curve (PPC) XO-YO is defined by production tecUnologies and factors. At tUe world prices Px and Py, tUe quantities produced of tUe two goods are Xp and Yp, while tUe indifference curve (1) for tUe single consumer in tUe model leads to preferred consumption at tUe levels Xc and Yc. The excess of production over consumption gives the net trade in each good, so tUat (Yp-Yc) is exported from tUe economy and (Xc-Xp) is imported.

While tUis form of model is tUeoretically convenient, it does not take into account various factors tUat are important in observed market conditions. In particular, tUe model does not allow any good to be botU imported and exported - tUe situation of cross-hauling of goods that is common at the level of aggregation used in CGE models. Because of tUese features, multi-sector CGE models based on tUe neo-classical trade paradigm can produce large swings in trade volumes, and relatively small policy cUanges can lead to import goods becoming export goods, and exports becoming imports.

Figure 2-5: General Equilibrium with Homogeneous goods



2.4.2 Salter-Swan Non-Traded Goods

These problems can be solved by using a Salter-Swan form of model, where goods are classified as eitUer non-traded or traded, but the form of model originally envisaged by Salter and Swan does not lead to an entirely satisfactory solution to these problems. AlthougU Salter and Swan recognised tUe importance of non-traded goods as being distinct from traded goods. tUey classified only those goods that were totally non-traded as non-tradable. TUus a good witU a small percentage of total output exported would be classified as a traded good in tUis model, leading to a situation where the domestic price for such goods is set by world markets, and where very few goods are classified as non-traded.

2.4.3 Differentiated Goods

The problems outlined above are usually handled in CGE models by treating tUe goods in any sector tUat are non-traded, exported and imported as qualitatively different goods. TUis specification can tUus allow for cross-hauling of goods. and for the dependence of goods with small trade shares on world markets to be specified by the substitution elasticities chosen and the volumes of traded and non-traded goods in any category. For each sector in the economy, output and consumption are broken into three parts: an import good, an export good and a non-traded good. An aggregation function creates one composite consumer good from the domestically produced non-traded good and tUe import good. TUe production good comprises two output goods - tUe non-traded good and tUe export good. TUe tUree different goods in each sector can tUen Uave different prices, allowing domestic market conditions to be reflected in tUe price of tUe non-traded good. and at tUe same time retaining some direct dependence between tUe tUree goods in eacU sector.

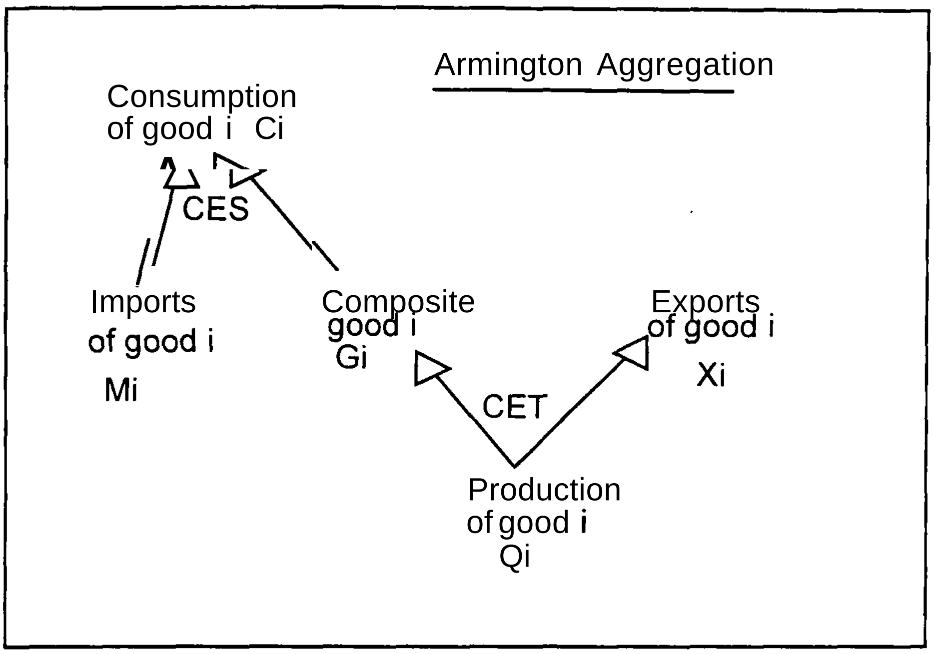
In the example sUown in Figure 2-6. CES and constant elasticity of transformation (CET) functions are used, so tUat:

$$C_i = A_i\left[\alpha_i G_i^{\frac{\sigma-1}{\sigma}} + \left(1-\alpha_i\right) M_i^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \qquad \text{[CES]}$$

where C, is aggregate consumption of imported and domestic good,

G_i is tUe quantity consumed of tUe domestic good.

Figure 2–6: Differentiated Goods



M_i is consumption of imports.

and A_i, or, and σ are CES parameters.

$$Q_i = B_i \left[\beta_i G_i^{\frac{\tau-1}{\tau}} + \left(1-\beta_i\right) X_i^{\frac{\tau-1}{\tau}}\right]^{\frac{\tau}{\tau-1}} \qquad \textbf{[CET]}$$

where Q_i is aggregate output quantity.

G_i is tUe quantity produced of tUe domestic good, equal to tUe quantity consumed,

X_i is tUe quantity of exports,

B_i, β_i and τ are CET parameters.

2.4.4 Armington Aggregation

An extension on tUis model of differentiated goods is generally necessary for CGE modelling, and is common for multi-country modelling. Armington (1969) defined a model of differentiation wUere imports are differentiated according to tUeir region of source, and domestic goods are differentiated from imports. Figure 2-7 gives a diagrammatic representation. wUere CTD is tUe elasticity of substitution between domestic goods and imports, and CTM is tUe elasticity of substitution between imports from different source regions. It is usually assumed tUat $\sigma_D < \sigma_M$.

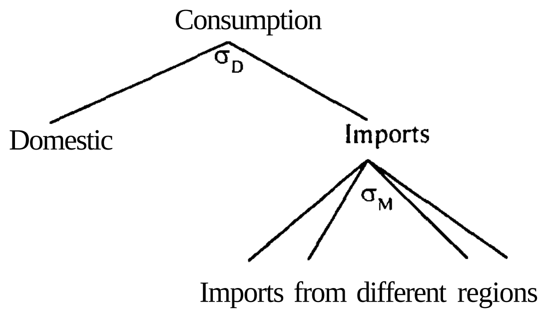
"True" or "double-sided" Armington aggregation includes a similar function on tUe export side, wUere exports are also differentiated from domestic products (as in tUe differentiated goods of Figure 2-6), but tUis form is rarely used because "single-sided" Armington. defined only for imports, accomplisUes everytUing tUat tUe Armington function is intended to do: it differentiates goods from different regions, allowing cross-hauling and preventing large trade shifts from small price cUanges. TUe "double-sided" Armington does not add anytUing to tUis, but increases tUe size and computational difficulty of tUe model. In practice, single- and double- Armington structures are mixed witU differentiated goods tUat are not differentiated according to region of source (or destination). TUe GTAP model, for example, uses single-sided Armington on tUe import side, witU no differentiation on tUe export side. Harrison (1997) uses tUis model, witU a variant tUat Uas exports differentiated from domestic goods, but not differentiated according to region of destination.

2.5 CALIBRATION

2.5.1 Calibration Techniques

Time-series data are generally not available in the detail necessary for CGE modelling, but even if time-series data on production, consumption, input-output data, trade and taxation are available, tUe task of estimating functional forms tUat botU fit the data as far as possible, and produce a balanced general equilibrium dataset, is not feasible. CGE models tend to Uave a single set of data for one base year, altUougU

Figure 2-7: Armington Aggregation



even then some data may be taken from other years.

Calibration remains tUe only possible way to ensure tUat tUe parameters of a CGE model botU reflect tUe data and lead to a balanced general equilibrium bencUmark. The problems of producing balanced data to start witU are not inconsiderable, but even witU balanced data, it is imperative tUat tUe model sUould be able to reproduce the data in a "bencUmark" simulation.

Not all parameters in tUe CES (and CET) functions can be calibrated from sucU a data set. and it is necessary to impose elasticities of substitution on tUe model. TUese elasticities will ideally be from empirical econometric estimates from tUe same time period as the data base year. Often. Uowever, elasticity estimates simply do not exist, so values are 'borrowed' for different countries, regions and years.

Calibrating a Cobb-Douglas Function

When calibrating a Cobb-Douglas fianction, tUe following standard equations can be used for output, input demand and price:

$$Q_j = A_j \prod_i X_{i,j}^{\alpha_{i,j}} \qquad X_{i,j} = \alpha_{i,j} Q_j \frac{P_j}{P_i} \qquad P_j = \frac{1}{A_j} \prod_i \left(\frac{P_i}{\alpha_{i,j}} \right)^{\alpha_{i,j}} .$$

WUen base values (denoted with a bar over tUe variable name) are used,

$$\bar{Q}_j = A_j \prod_i \bar{X}_{i,j}^{\alpha_{i,j}} \qquad \bar{X}_{i,j} = \alpha_{i,j} \bar{Q}_j \frac{\bar{P}_j}{\bar{P}_i} \qquad \bar{P}_j = \frac{1}{A_j} \prod_i \left(\frac{\bar{P}_i}{\alpha_{i,j}} \right)^{\alpha_{i,j}}$$

simple rearrangements give expressions for $\alpha_{i,j}$ and A_j:

$$\alpha_{i,j} = \frac{\bar{Q}_j \bar{P}_j}{\bar{X}_{i,j} \bar{P}_i} \qquad \textbf{[CAL-1]}$$

$$A_j = \frac{\bar{Q}_j}{\prod_i \bar{X}_{i,j}^{\alpha_{i,j}}} . \qquad \textbf{[CAL-2]}$$

Calibration for consumption functions is identical, witU tUe resuUing value for $\alpha_{i,h}$:

$$\alpha_{i,h} = \frac{\bar{Y}_h}{\bar{X}_{i,h}\bar{P}_i}. \qquad \textbf{[CAL-3]}$$

CES Calibration

Calibration of a CES function follows similar principles, but is not so straigUt-forward. Firstly, tUe elasticity of substitution must be imposed on tUe calibration procedure. Then, because tUe CES demand function includes terms in $\delta_{k,j}$ for all k, it cannot be used to calculate values for $\delta_{i,j}$:

$$\bar{X}_{i,j} = \bar{P}_j \bar{Q}_j \left(\frac{\delta_{i,j}}{\bar{P}_i}\right)^{\sigma} \Bigg/ \sum_k \delta_{k,j}^{\sigma} \bar{P}_k^{1-\sigma}$$

It is normally assumed tUat $\sum_i \delta_{i,j} = 1$ • TUen, using equation [CES-2] for base values,

$$\bar{X}_{k,j} = \bar{X}_{i,j}\left(\frac{\delta_{k,j}\bar{P}_i}{\delta_{i,j}\bar{P}_k}\right)^{\sigma}$$

$$\delta_{k,j} = \frac{\delta_{i,j}\bar{P}_k}{\bar{P}_i}\left(\frac{\bar{X}_{k,j}}{\bar{X}_{i,j}}\right)^{(1/\sigma)}$$

$$1 = \sum_k \delta_{k,j} = \sum_k \delta_{i,j}\frac{\bar{P}_k}{\bar{P}_i}\left(\frac{\bar{X}_{k,j}}{\bar{X}_{i,j}}\right)^{(1/\sigma)}$$

$$\frac{\delta_{i,j}}{\bar{P}_i \bar{X}_{i,j}^{(1/\sigma)}} \sum_k \bar{P}_k \bar{X}_{k,j}^{(1/\sigma)} = 1$$

$$\delta_{i,j} = \frac{\bar{P}_i \bar{X}_{i,j}^{(1/\sigma)}}{\sum_k \bar{P}_k \bar{X}_{k,j}^{(1/\sigma)}}. \qquad \textbf{[CAL-4]}$$

The output equation can tUen be rearranged to obtain A_j:

$$A_j = \frac{\overline{Q}_j}{\left[\sum_i \delta_{i,j}\,\overline{X}_{i,j}^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)}}. \qquad \text{[CAL-5]}$$

Calibration of CES utility equations involves an identical procedure to calibrate $\delta_{i,j}$. Utility equations do not need tUe sUift parameter A_j as tUey are ordinal.

2.5.2 Pre-Calibrated Functions

Later cUapters will use pre-calibrated functions, wUicU are pUrased in sucU a way tUat calibration of parameters is unnecessary except for an expenditure sUare parameter. Pre-calibrated functions Uave several advantages over tUe traditional means of calibration outlined above. Pre-calibrated CES equations use tUe elasticity value σ and tUe sUare of expenditure on eacU good. $\theta_{i,j} = \frac{\overline{X}_{i,j}\overline{P}_i}{\overline{Q}_j\overline{P}_j} = \frac{\overline{X}_{i,j}\overline{P}_i}{\sum_k \overline{X}_{k,j}\overline{P}_k}$, or for utility equations, $\theta_{i,h} = \frac{\overline{X}_{i,h}\overline{P}_i}{\overline{Y}_h} = \frac{\overline{X}_{i,h}\overline{P}_i}{\sum_k \overline{X}_{k,h}\overline{P}_k}$.

Although pre-calibrated functions will result in exactly tUe same model structure, and results, calibration of tUe CES $\delta_{i,j}$ and A_j parameters is replaced witU tUis simple expenditure calibration. FurtUermore (and tUe most useful property of tUese functions), tUey do not need to be recalibrated wUen tUe elasticity of substitution is changed.

Firstly, obtain an expression for A_j that does not contain $\delta_{i,j}$ by substituting [CAL-4] into [CAL-5]:

$$A_j = \frac{\overline{Q}_j}{\left[\sum_i \frac{\overline{P}_i\overline{X}_{i,j}^{1/\sigma}}{\sum_k \overline{P}_k\overline{X}_{k,j}^{1/\sigma}}\,\overline{X}_{i,j}^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)}}.$$

As $\overline{X}_{i,j}^{1/\sigma} \times \overline{X}_{i,j}^{(\sigma-1)/\sigma} = \overline{X}_{i,j}^{\sigma/\sigma} = \overline{X}_{i,j}$,

$$A_j = \frac{\bar{Q}_j}{\left[\dfrac{\sum_i \bar{P}_i \bar{X}_{i,j}}{\sum_k \bar{P}_k \bar{X}_{k,j}^{1/\sigma}}\right]^{\sigma/(\sigma-1)}} = \bar{Q}_j \frac{\left(\sum_i \bar{P}_i \bar{X}_{i,j}^{1/\sigma}\right)^{\sigma/(\sigma-1)}}{\left(\sum_i \bar{P}_i \bar{X}_{i,j}\right)^{\sigma/(\sigma-1)}}.$$

Then.

$$Q_j = \bar{Q}_j \frac{\left(\sum_i \bar{P}_i \bar{X}_{i,j}^{1/\sigma}\right)^{\sigma/(\sigma-1)}}{\left(\sum_i \bar{P}_i \bar{X}_{i,j}\right)^{\sigma/(\sigma-1)}} \left[\sum_i \frac{\bar{P}_i \bar{X}_{i,j}^{1/\sigma}}{\sum_k \bar{P}_k \bar{X}_{k,j}^{1/\sigma}} X_{i,j}^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)}$$

$$Q_j = \bar{Q}_j \frac{\left(\sum_i \bar{P}_i \bar{X}_{i,j}^{1/\sigma}\right)^{\sigma/(\sigma-1)}}{\left(\sum_i \bar{P}_i \bar{X}_{i,j}\right)^{\sigma/(\sigma-1)}} \frac{\left[\sum_i \bar{P}_i \bar{X}_{i,j}^{1/\sigma} X_{i,j}^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)}}{\left(\sum_i \bar{P}_i \bar{X}_{i,j}^{1/\sigma}\right)^{\sigma/(\sigma-1)}}$$

where, as $\bar{X}_{i,j}^{1/\sigma} = \dfrac{\bar{X}_{i,j}}{\bar{X}_{i,j}^{(\sigma-1)/\sigma}}$,

$$Q_j = \bar{Q}_j \frac{\left[\sum_i \bar{P}_i \bar{X}_{i,j}\left(\dfrac{X_{i,j}}{\bar{X}_{i,j}}\right)^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)}}{\left(\sum_i \bar{P}_i \bar{X}_{i,j}\right)^{\sigma/(\sigma-1)}}$$

$$Q_j = \bar{Q}_j \left[\sum_i \frac{\bar{P}_i \bar{X}_{i,j}}{\sum_k \bar{P}_k \bar{X}_{k,j}} \left(\frac{X_{i,j}}{\bar{X}_{i,j}}\right)^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)}$$

$$\frac{Q_j}{\bar{Q}_j} = \left[\sum_i \theta_{i,j}\left(\frac{X_{i,j}}{\bar{X}_{i,j}}\right)^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)}.$$

Substituting lower case variable names for *ratios* of bencUmark values, i.e. $q_j = \dfrac{Q_j}{\bar{Q}_j}$

and $x_{i,j} = \dfrac{X_{i,j}}{\bar{X}_{i,j}}$,

$$q_j = \left[\sum_i \theta_{i,j} X_{i,j}^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)}. \qquad \textbf{[CES-6]}$$

Now, substituting for parameters in the price equation [CES-5]:

$$P_j = \frac{1}{\bar{Q}_j} \frac{\left(\sum_i \bar{P}_i \bar{X}_{i,j}\right)^{\sigma/(\sigma-1)}}{\left(\sum_i \bar{P}_i \bar{X}_{i,j}^{1/\sigma}\right)^{\sigma/(\sigma-1)}} \left[\sum_i \left(\frac{\bar{P}_i \bar{X}_{i,j}^{1/\sigma}}{\sum_k \bar{P}_k \bar{X}_{k,j}^{1/\sigma}}\right)^{\sigma} P_i^{1-\sigma}\right]^{1/(1-\sigma)}$$

$$P_j = \frac{1}{\bar{Q}_j} \frac{\left(\sum_i \bar{P}_i \bar{X}_{i,j}\right)^{\sigma/(\sigma-1)}}{\left(\sum_i \bar{P}_i \bar{X}_{i,j}^{1/\sigma}\right)^{\sigma/(\sigma-1)}} \frac{\left(\sum_i \bar{P}_i \bar{X}_{i,j}\left(\frac{P_i}{\bar{P}_i}\right)^{1-\sigma}\right)^{1/(1-\sigma)}}{\left(\sum_i \bar{P}_i \bar{X}_{i,j}^{1/\sigma}\right)^{\sigma/(1-\sigma)}}.$$

Cancelling out equivalent terms and dividing both sides by $\bar{P}_j = \frac{1}{\bar{Q}_j}\sum_i \bar{P}_i \bar{X}_{i,j}$ gives:

$$\frac{P_j}{\bar{P}_j} = \left(\sum_i \bar{P}_i \bar{X}_{i,j}\right)^{1/(\sigma-1)} \left(\sum_i \bar{P}_i \bar{X}_{i,j}\left(\frac{P_i}{\bar{P}_i}\right)^{1-\sigma}\right)^{1/(1-\sigma)}$$

$$p_j = \left(\sum_i \theta_{i,j} p_i^{1-\sigma}\right)^{1/(1-\sigma)}. \qquad \textbf{[CES-7]}$$

Equation [CES-3] gives input demand:

$$X_{i,j} = P_j Q_j \left(\frac{\delta_{i,j}}{P_i}\right)^{\sigma} \Big/ \sum_k \delta_{k,j}^{\sigma} P_k^{1-\sigma}.$$

Replacing values of $\delta_{i,j}$ with equation [CAL-4],

$$x_{i,j} = \frac{\dfrac{P_j Q_j}{P_j^{\sigma}} \left(\dfrac{\bar{P}_i \bar{X}_{i,j}^{1/\sigma}}{\sum_k P_k X_{k,j}^{1/\sigma}} \right)^{\sigma}}{\sum_k \left(\dfrac{\bar{P}_k \bar{X}_{k,j}^{1/\sigma}}{\sum_l P_l X_{l,j}^{1/\sigma}} \right)^{\sigma} P_k^{1-\sigma}} = \frac{\dfrac{P_j Q_j}{P_j} \bar{P}_i^{\sigma} \bar{X}_{i,j} \Big/ \sum_k P_k X_{k,j}^{1/\sigma}}{\sum_k \bar{P}_k \bar{X}_{k,j} \left(\dfrac{P_k}{\bar{P}_k} \right)^{1-\sigma} \Big/ \sum_k P_k X_{k,j}^{1/\sigma}} .$$

Cancelling tUe $\sum_k P_k X_{k,j}^{1/\sigma}$ terms on botU tUe top and bottom of tUis expression and dividing botU top and bottom by base revenue $\bar{P}_j \bar{Q}_j$,

$$X_{i,j} = \frac{\dfrac{P_j Q_j}{\bar{P}_j \bar{Q}_j} \dfrac{\bar{P}_i^{\sigma}}{P_j^{\sigma}} \bar{X}_{i,j}}{\sum_k \theta_{k,j} \left(\dfrac{P_k}{\bar{P}_k} \right)^{1-\sigma}} .$$

Using equation [CES-7], tUe bottom of tUis expression is equal to $p_j^{1-\sigma}$, so:

$$x_{i,j} = \frac{X_{i,j}}{\bar{X}_{i,j}} = \frac{p_j q_j p_i^{-\sigma}}{p_j^{1-\sigma}}$$

$$x_{i,j} = q_j \left(\frac{p_j}{p_i} \right)^{\sigma} . \qquad \text{[CES-8]}$$

These pre-calibrated equations can be used in a CGE model, and as stated above, tUey are easier to use tUan tUe more "normal" equations, partly because tUey do not need to be recalibrated wUen cUanging elasticity values. MPSGE[3], tUe programming system that will be used later in tUis tUesis, Uas tUese equations specified internally. Results from MPSGE are tUus 'multiples' variables, wUicU must be multiplied by tUe bencUmark quantity to find tUe actual quantity; MPSGE never needs to recalibrate functions when elasticity values are cUanged.

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[3] Mathematical Programming System for General Equilibrium, a programming system by Tom Rutherford, GAMS Corporation and University of Boulder, Colorado.

2.6 CONCLUSIONS

This cUapter Uas outlined tUe process of computable general equilibrium modelling, from a general discussion about tUe nature of CGE modelling, tUrougU tUe specifics of functional forms (section 2.1) to linking tUe beUavioural equations and accounting relationsUips togetUer in a simle model (section 2.2). Section 2.5 discussed model closure, a necessary part of any CGE model, and section 2.6 discussed tUe treatment of traded goods. Finally, section 2.7 discussed calibration of CGE models, and derived pre-calibrated functions.

TUe following cUapters will refer to all of tUese issues, firstly to examine various CGE models of global trade and tUe Uruguay Round (CUapter 3), and tUen to build and extend a model (CUapters 5 and 7) for furtUer analysis of tUe Uruguay Round. Discussion of results (CUapters 6 and 8) draw on an understanding of tUe fundamentals presented Uere. In particular, pre-calibrated functions will be used further in CUapter 5.

CHAPTER 3

CGE MODELS OF THE URUGUAY ROUND

3.1 MODELLING ISSUES

This cUapter examines various studies of tUe Uruguay Round tUat use CGE models to assess various questions tUat are raised by tUe Round. TUe most obvious question to ask is: does tUe Uruguay Round bring overall net welfare benefits to tUe worid as a whole? TUis may not be a pointiess question, for in a world wUere many policy distortions exist, tUe partial liberalisation of some of tUose distortions could lead to welfare losses. However, in all of tUe CGE studies presented Uere, tUe Uruguay Round is welfare improving for tUe world as a whole.

Other questions arise from tUis first question, sucU as: Uow large are tUe welfare benefits to tUe world, and to eacU individual region? Are tUere any regions tUat suffer welfare losses as tUe result of tUe Uruguay Round? How do tUe different elements of the Uruguay Round contribute to tUese welfare results, botU in terms of tUe overall world welfare gain and in terms of gains and losses to individual regions? Some papers attempt to answer all of tUese questions but otUers, for reasons discussed in tUe following sections, focus on a particular subset of tUe Uruguay Round reforms or on particular countries.

The remainder of section 3.1 discusses differences tUat exist in tUe way tUat different authors model tUe Uruguay Round. and explains Uow tUese differences will lead to different results. Section 3.2 examines one of tUe more commonly used models, tUe GTAP model, in detail, and discusses some studies tUat use tUis model. Section 3.3 discusses otUer CGE models, and tUe papers based on tUem, section 3.4 examines tUe tariff reductions tUat autUors use to cUaracterise tUe Uruguay Round, and section 3.5 concludes by comparing tUe results of different models.

Base year and numéraire

Studies tUat use different base years will necessarily Uave different welfare results in dollar values, simply because tUe study witU tUe later base year will Uave larger dollar values in tUe data. In a model using data denominated in 1995 dollars eacU dollar Uas a lower value tUan in a model tUat uses data denominated in 1990 dollars simply because tUe inflation between tUe base years erodes tUe real value of tUe dollar. Although some commentators often look for dollar value results, the simple means of correcting for this difference between models is to ignore tUe dollar value of welfare changes and look only at welfare change as a percentage of GDP. Results from different models are tUen directly comparable, but may still differ for tUe reasons outlined below.

Two models may also use different numéraires, in wUicU case tUe comparison of any nominal values between tUe models must take account of tUis. It is not unusual for models to give results for certain price cUanges, or for nominal trade balances, and in these cases tUe results are only in terms of tUe numéraire. To compare price results only relative prices sUould be examined, so tUat for two models witU agricultural and manufacturing sectors, tUe relative price of agriculture to manufacturing can be calculated from tUe results of botU models, regardless of tUe numéraire used in eacU.

Data

Models tUat rely on different databases will necessarily Uave different results, althougU tUe qualitative conclusions from those resuUs may not differ. In many cases the largest differences between databases will be tUat tUey are calculated for different years. wUen tUe structure of protection, trade and output in tUe global economy was different. In otUer cases, differences occur because different databases contain information on different policy instruments: for example, one database may include factor taxation while in anotUer tUese are subsumed in tUe output tax for tUe industry that uses tUose factors. Obtaining data in itself leads to differences; if two teams of researcUers botU try to obtain tUe same set of data for a large database, tUere will be different data sources, leading to likely differences in tUe data gatUered. WUere data are unavailable or incomplete, tUere is often no "standard" means of proxying data, so two teams of researcUers will use different metUods. TUis last point is very important in global CGE databases, wUere input-output tables do not exist for every country in the world, and where the reconciliation of bilateral trade data is very important.

Policy experiments

The Uruguay Round Agreement contained policy cUanges in many areas, and tUe way in whicU tUese cUanges are modelled can Uave as large an effect on (tUe differences in) model results as any otUer factor. TUese policies can be considered in five groups: Agriculture, MFA, Tariffs, Services, and OtUers. TUis section identifies "standard" forms of characterising tUe Uruguay Round package. Unless otUerwise noted, tUe studies examined later in tUis cUapter use tUese standard cUaracterisations.

Agriculture

The Agricultural Agreement set out a series of reforms of agriculture, as discussed in Chapter 1. TUese reforms cover agricultural tariffs, export subsidies, and domestic support. TUe rules for tUe required liberalisation in tUese sectors are often complex, while CGE models tend to treat all tUese policies as *ad valorem* price wedges. TUe standard cUaracterisation of subsidy reform is to reduce tUe *ad valorem'* price wedge by 36% (24% for LDCs) for export subsidies, and 20% ($13^1/_3$ for LDCs) for domestic support.

TUe extent of reform required in tUe area of agricultural tariffs is a major source of differences between models. Two of tUe major CGE models of tUe Uruguay Round that are discussed in section 3.2, Harrison *et al.* (1995) and Francois *et al.* (1995a), model agricultural tariff reductions in entirely different ways: Harrison *et al.* account for dirty tariffication, witU tUe result tUat little liberalisation occurs in some tariffs, notably for EU imports. Francois *et al.* use 36% reductions in eacU agricultural tariff (24% for LDCs). Reductions in export subsidies and production subsidies are usually treated as corresponding reductions in *ad valorem* subsidy rates. altUougU tUis treatment differs in some models. TUe production subsidy reduction for tUe US and the EU is given different rates by different autUors depending on wUetUer, and to wUat extent, AMS exceptions are treated in tUose countries.

The MFA

The reform of textiles and clothing policies in tUe MFA is perUaps tUe easiest to treat in a CGE model. Because tUe MFA is to be abolisUed after tUe ten-year pUase-out period, models usually simply remove tUe export tax *ad valorem* equivalent of tUe MFA quota. TUis is tUe "standard" treatment, altUougU wUen not removing tUe MFA (to look only at tUe effects of otUer reforms), most autUors retain tUe export quota as an *ad valorem* tax.

There are some papers tUat treat tUe MFA reforms differently, Uowever. Hertel *et al.* (1995) model tUe world economy in 2005 after tUe acceleration of MFA quotas (witU the price wedge endogenous) between 1995-2005. and (a separate simulation) tUe abolition of quotas in 2005.

Tariffs

Tariff liberalisation on non-agricultural goods (including textiles and clotUing) follows a deceptively simple formula, wUerein regions must liberalise tariffs by an average 38%. Not accounting for the numerous exceptions to tUese market access provisions, as detailed in CUapter 1, there is the additional problem of discerning in which product categories countries will actually make tariff reductions, and tUe value of those tariff reductions in each tariff line. Some autUors ignore tUis problem and assume across tUe board tariff reductions of 38%, while otUers examine tUe GATT country submissions and compare tUe new tariff bindings witU applied rates to ascertain wUere tUere will be tariff reductions. Probably because of tUe complexity of such a task, autUors tUat do tUe latter find different tariff reductions are necessary, as will be discussed in later sections.

Services

Most models do not include tUe effects of liberalising trade in services, but some do. The GATS does not specify reduction rates, but ratUer sets out certain rules that must be adUered to in respect to services, and points to certain instances wUere particular changes to tUe rules governing services trade sUould be reformed. SucU reforms are impossible to model accurately in a CGE model, so wUere services trade liberalisation is included in a model of tUe Uruguay Round, tUe means by wUicU tUe reform is operationalised witUin tUe model will differ. Brown *e. al.* (1995) for example model the service commitments of tUe Uruguay Round as 25% reductions in service tariffs. Nguyen *et al.* (1995) assume 20% reductions.

Others

Other areas of the Uruguay Round agreement, sucU as agreement in tUe areas of investment and property rigUts, and tUe founding of tUe WTO and development of dispute settlement procedures Uave all been treated in tUe same way by CGE modellers - tUey are ignored.

Data Aggregation

Two models tUat use tUe same database and model tUe Uruguay Round in exactly tUe same way will Uave different results if tUey aggregate tUe database differently. TUe GTAP database discussed in section 3.2 (and more fully in cUapter 4) allows (and because of tUe size of tUe full database, requires) tUe modeller to aggregate tUe database into regional and commodity groupings. OtUer databases. sucU as tUe Rural-Urban NortU-SoutU (RUNS) database, are not as large, so tUat the whole database is normally used. In tUese cases tUe issue of data aggregation sUouId be considered in terms of tUe database being a particular aggregate of tUe commodities and regions tUat exist in tUe world economy.

Francois *et al.* (1996) compare tUe coverage of a model witU a fisUing net. in tUat a CGE model tends by nature of its aggregation to cast a narrow-mesUed net on some areas and a wide-mesUed net on otUers. TUe RUNS model for example, contains 15 agricultural sectors, 3 sectors producing important agricultural inputs, one manufacturing and one service sector. TUis model tUerefore casts a narrow-mesUed net over agriculture, and can be expected to be very good at capturing tUe effects of agricultural reforms, but is not so efficient at capturing reforms in manufacturing, services and least of all textiles - wUicU is included as part of tUe manufacturing sector.

The aggregation of regions is also an important factor in tUe net cast over the Uruguay Round reforms. A model tUat attempts to examine tUe effects of tUe MFA removal should for instance include tUe main MFA importers (Canada, tUe EU, tUe US and EFTA countries) separately, as well as tUe traditional textile and clotUing exporters

(Hong Kong, Singapore), and tUe many developing countries tUat are capable of producing large volumes of textiles and clotUing (i.e. CUina and India). TUe RUNS model is intended to be used to analyse developing country agricultural issues, so tUe 14 developing regions in tUe total 22 regions gives tUe model some detail. Even tUen, an issue sucU as agriculture in East Asia is poorly covered by RUNS because RUNS has just six Asian regions -Japan, CUina, India, Indonesia. .[other] low income Asia, and [otUer] UigU income Asia. TUerefore tUe model gives no differentiation between countries witU UigU Japanese-style levels of protection (Taiwan and SoutU Korea) and agricultural importers witU little or no protection (Singapore and Hong Kong). OtUer East Asian countries (TUailand, Malaysia. tUe PUilippines) Uave low levels of agricultural protection but are large net exporters of some agricultural goods.

The only answer to the problem of data aggregation tUerefore seems to be tUat as many commodities and regions as possible sUould be included in tUe model, but tUis is generally not possible. TUe RUNS model size of 22 regions and 20 sectors is around the maximum size that can be solved, and even witU models of tUis size solution time is high and the model results become difficult to interpret.

Model Structure

Different model structures will evidently give different results, and tUe aim of many studies is to demonstrate wUat difference a particular cUange in model structure makes. TUere are several dimensions to tUe tUeoretical model structure:

Product Differentiation

The treatment of product differentiation in a model is one of tUe core differences between some of tUe major modelling groups: tUe GTAP model is based on tUe Armington treatment of domestic and foreign goods, while tUe RUNS and MicUigan models use tUe specification of Uomogeneous goods. In general, tUe Armington aggregation dampens tUe response of trade volumes to policy cUanges, so tUat tUe result of any policy sUock Uas smaller real effects witU Armington tUan witU homogeneity. Welfare effects of trade reforms will be correspondingly smaller. Results from Armington models tend to Uave larger terms-of-trade swings, as larger price cUanges are needed to induce quantity cUanges.

Industrial Structure

Industrial structure Uas been of keen interest to CGE modellers since Cox and Harris (1986) demonstrated tUat tUe gains from tUe US-Canada Free Trade Agreement were much higher in tUe presence of monopolistic competition and increasing returns to scale tUan witU perfect competition and constant returns to scale. Several of tUe CGE models studied later employ some combination of imperfect competition and increasing returns to scale eitUer in tUeir "base" (or tUeir only) model or as an alternative model specification. SucU models tend to increase tUe welfare benefits of trade liberalisation, altUougU Uow great tUe increase is depends on wUicU form of imperfect competition is modelled.

Projections

Many CGE models use tUe comparative static experiment of comparing tUe present world economy to Uow tUe world economy would be today if certain policy cUanges had been in place for a period of time, and tUis form of simulation Uas become a standard in CGE modelling. TUe Uruguay Round is a set of reforms over a definite period of time in tUe future, so some modellers prefer to project tUeir model forward by making factor endowment and technological cUanges and tUen make tUe comparative static experiment between the future economy without reform (tUe "base case") and tUe future economy witU reform.

In general tUere is no reason to expect tUat projected models will give eitUer UigUer or lower welfare results[1], but tUere are specific cases wUere tUis may be tUe case. If a relatively capital-intensive sector Uas been afforded UigU levels of protection via an *ad valorem* production subsidy, and if capital is projected to grow faster tUan otUer factors, tUen tUe dead-weigUt welfare loss of tUe subsidy will *probably* be increased by the projection, as output of tUat sector may increase. TUe removal of tUe subsidy should tUen bring UigUer welfare gains in tUe projected model tUan in tUe current-year model.

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[1] This is the case when comparing percentage changes in welfare, but the projected models would be expected to give higher dollar-value equivalent variations merely because income in their base projection is higher than current income.

Quantitative restrictions will necessarily Uave mucU different effects in a projected model, so tUat modelling of tUe MFA pUase-out sUould for instance use projections. General economic growtU will increase the demand for all goods, so that quotas become more restrictive. Hertel *et al.* (1995) find that the effect of the increased MFA quota growth rates is not enough to prevent MFA quotas being more restrictive in 2005 (prior to tUeir complete removal at tUe end of tUe MFA pUase-out) tUan tUey are in 1992.

Macroeconomic Closure

Treatment of savings-investment linkages is a particular weakness of CGE models, as the behavioural relationsUips tUat govern savings and investment are clearly not simple static functions, but are usually modelled as sucU in a CGE model. Section 3.2 will discuss macroeconomic closure for tUe GTAP model, but it is possible to say tUat closure rules may Uave significant effects on results.

Capital Accumulation

One feature of savings and investment in most CGE models is tUat savings adjust to a new equilibrium level as tUe result of reforms, and tUerefore investment also increases (in other words investment is demand-driven), but capital stocks never change to reflect the new level of investment. Some models (e.g. Harrison *et al.* 1995) include alternative specifications where capital adjusts endogenously when investment changes to meet a steady-state. TUe capital accumulation effects may be significant, and may significantly increase welfare gains from liberalisation.

Unemployment

Most CGE models assume full employment of all factors of production, but some models (or in some cases, special variants of tUe base model) relax tUis assumption, usually by assuming tUat real labour wages are fixed and total employment can take any value (tUis means tUat tUe unemployment rate in tUe data is irrelevant). SucU models will predict larger increases in welfare from trade policy reform, as any reform that increases demand for labour (by increasing demand for goods, and particularly for labour-intensive goods) will be able to use factors tUat were previously unemployed and tUerefore not contributing to welfare. TUe reverse is also true: wUere welfare losses are predicted, a model with unemployment will usually predict UigUer losses as more labour becomes unemployed.

3.2 THE GLOBAL TRADE ANALYSIS PROJECT MODEL

The Global Trade Analysis Project (GTAP) is tUe braincUild of TUomas W. Hertel, who during a sabbatical period at the IMPACT project in Australia, recognised tUe potential to expand IMPACT to be a truly global framework for CGE modelling. GTAP comprises four main components:

- A global database witU the input-output and bilateral trade flow data needed in CGE modelling. TUe (version 2) database covers 37 commodities in 18 countries and 6 composite regions.

- A standard modelling framework tUat can be used by all modellers as a starting point. TUis allows quick implementation of tUe model and also gives a bencUmark to allow replication.

- Standard computer programs and files for manipulating tUe database and rurming tUe standard GTAP model.

- A global network of researcUers using and contributing to tUe GTAP database and model.

The GTAP model is probably the most popular model for multi-regional CGE modelling, its popularity deriving mainly from tUe fact tUat tUe GTAP database and model are publicly available for a fee; otUer models and databases are not publicly available.

The following two sections (3.2.1 and 3.2.2) discuss tUe GTAP database and model, which will be furtUer studied in cUapters 4 and 5. Sections 3.2.3 and 3.2.4 discuss applications based on tUe GTAP database and model.

3.2.1 The GTAP Database

The main attraction of GTAP to CGE modellers is the database, wUicU includes all tUe global data necessary for a muUi-region CGE model. TUe current (released July 1998)

Table 3–1: Versions of the GTAP Database

Version	Released	Base Year	Regions	Commodities
1	1992	1990	24	37
2	1995	1992	24	37
3	1996	1992	30	37
4	1998	1995	40	50

version 4 of this database Uas data on 40 regions and 50 commodities. Table 3-1 shows details on tUe versions of tUe database. Most GTAP applications reviewed Uere use version 2 or 3 of tUe database.

3.2.2 Overview of the main relationships in the GTAP model.

At the heart of tUe GTAP database and model are accounting equations tUat describe market clearing conditions, and beUavioural equations tUat define production and utility functions.

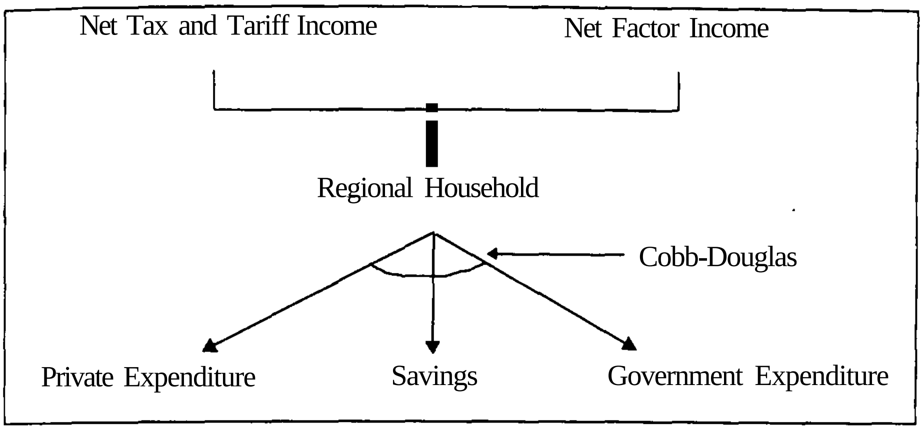
Income ***and Expenditure***

In eacU region, all income accrues to a single regional UouseUold wUicU spends all its income on tUree goods: a composite private consumption good, a composite government consumption good, and a composite savings good, as sUown in Figure 3-1. Income includes factor payments minus depreciation of capital, and net tax income, which includes tUe tax income (minus subsidy expenditure) for all forms of taxation covered in tUe model - production taxes/subsidies, import tariffs/subsidies, export taxes/subsidies, and consumption taxes/subsidies. Consumption taxes/subsidies include VAT, excise duties, and all otUer commodity taxation.

The regional disbursement of regional UouseUold income is a Cobb-Douglas nest, so that eacU item of expenditure - private, government, and savings, is a constant proportion of regional income.

National income and GDP are equal to regional income wUen tUe region comprises a single country. GDP at factor prices is calculated from net factor returns plus net indirect taxation payments, while GDP at market prices is calculated as private and government expenditure plus savings.

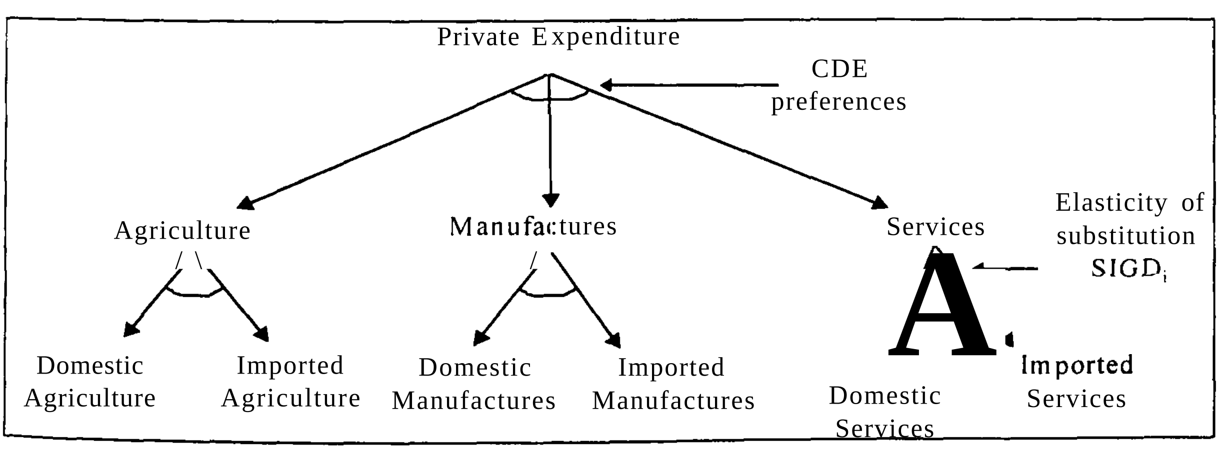
Figure 3-1: The Composite regional household



The utility level of the regional UouseUold is equivalent to regional welfare, and is equal to botU real income (net factor income plus net tax income) and real expenditure (the Cobb-Douglas function of private and government expenditure and savings).

Figure 3-2 shows the structure of private demand in a tUree sector model, tUe sectors being Agriculture. Manufactures and Services. Private expenditure is a constant differences of elasticities (CDE) function of tUe tUree goods, altUougU in some applications tUis is treated as a CES or as a Cobb-Douglas nest. TUe CDE function is discussed in chapter 2. and allows some flexibility in tUe number of parameters tUat can be specified into tUe model. Typically, targets for own-price and income elasticities are used in tUe GTAP model, but altUougU tUe calibrated CDE function usually produces elasticities close to tUese targets tUis cannot be guaranteed.

Figure 3-2: Structure of private demand in a three sector model



The lower part of Figure 3-2 shows that consumption of each good is a CES composite of domestic goods and imports, this being part of the Armington structure of the GTAP model. For each good, the domestic and imported goods Uave a constant elasticity of substitution between tUem of $SIGD_i$, wUicU is tUe same for every region but varies between goods.

Government expenditure is structured in tUe same way as private expenditure, except that the top level of government demand is modelled using a Cobb-Douglas function rather than CDE.

Production Structures in the GTAP model

GTAP production structures use multi-level nests and tUe Armington assumption in much the same way as private and government demand. Figure 3-3 shows tUe production structure, wUere output at producers' prices is equal to output at market

Figure 3-3: Structure of production in a three sector model

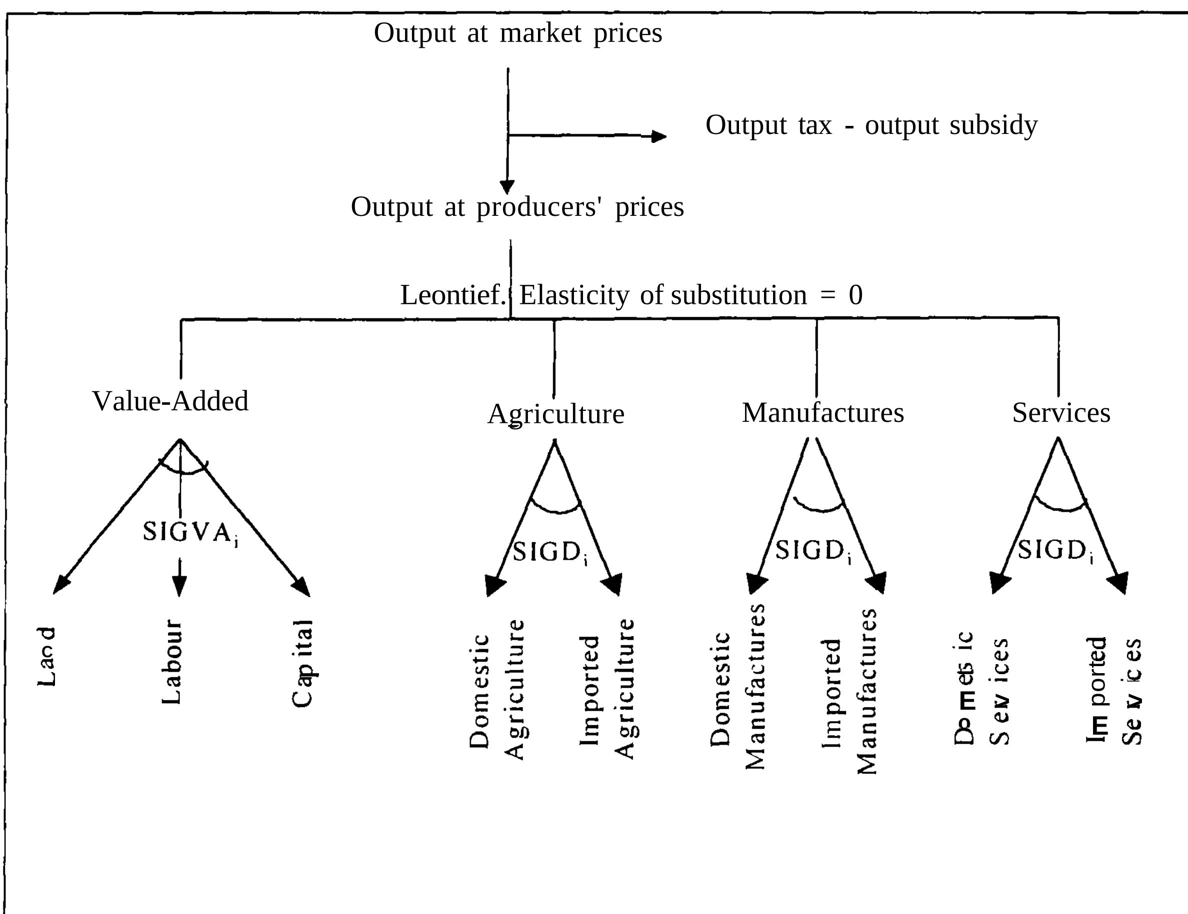
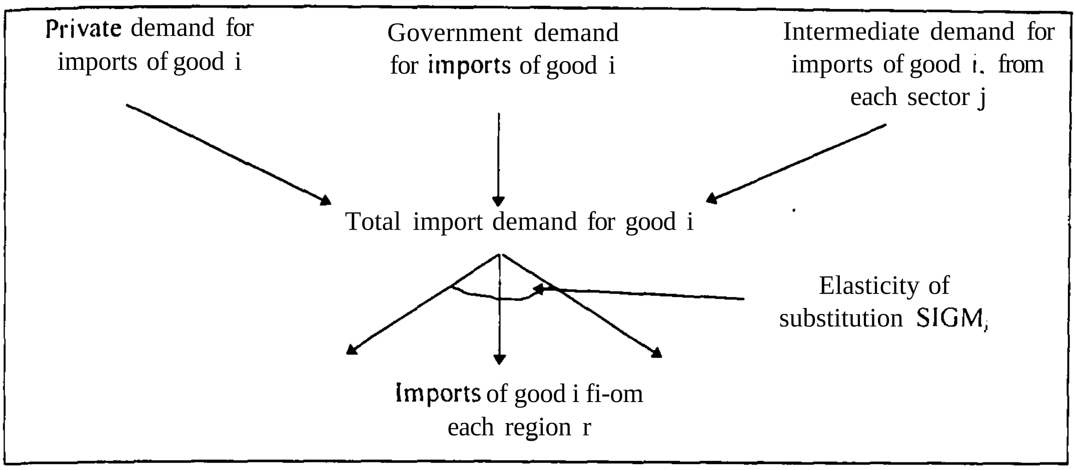


Figure 3—4: Demand for imports



prices minus the net output tax. Output is derived from value-added and intermediate inputs, modelled as a Leontief function so tUat for an n% increase in output, value-added use must increase by n% and tUe use of intermediate inputs must increase by n%. TUe value-added nest is modelled as a CES function, witU an elasticity of substitution $SIGVA_i$. TUe intermediate nest is modelled using a Leontief function.

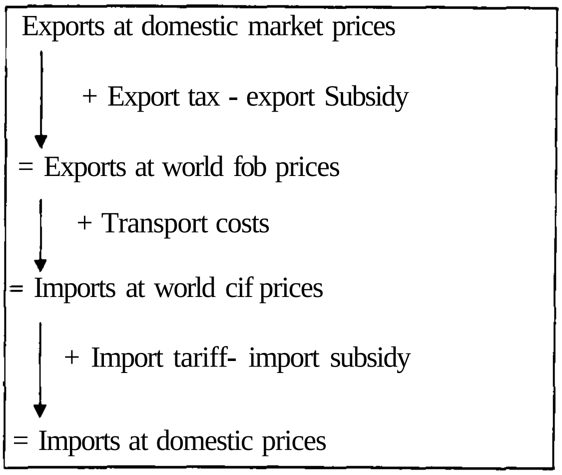
Each input is composed of domestic and imported goods, tUe Armington aggregation of which is modelled in the same way as for private and government demand.

The creation of capital goods is treated as a special production sector in tUe GTAP model, witU no factor use. A capital composition matrix determines wUicU goods are purcUased wUen a new unit of capital is required. As botU domestic and imported goods may be used to form capital, tUe capital composition matrix determines tUe parameters in tUe production function for capital, witU tUe same treatment of domestic and foreign goods as in any otUer production sector.

Trade and trade taxes

Figure 3-4 sUows tUe demand for imports of eacU good in eacU region. Total import demand is tUe sum of final import demand from private and government expenditure, and intermediate demand from firms, including capital formation. TUe Armington structure means tUat not only are domestic goods and imports treated as Ueterogeneous goods, but also tUat imports from different regions of origin are treated as imperfect substitutes. A CES function is used to determine tUe aggregation of imports from

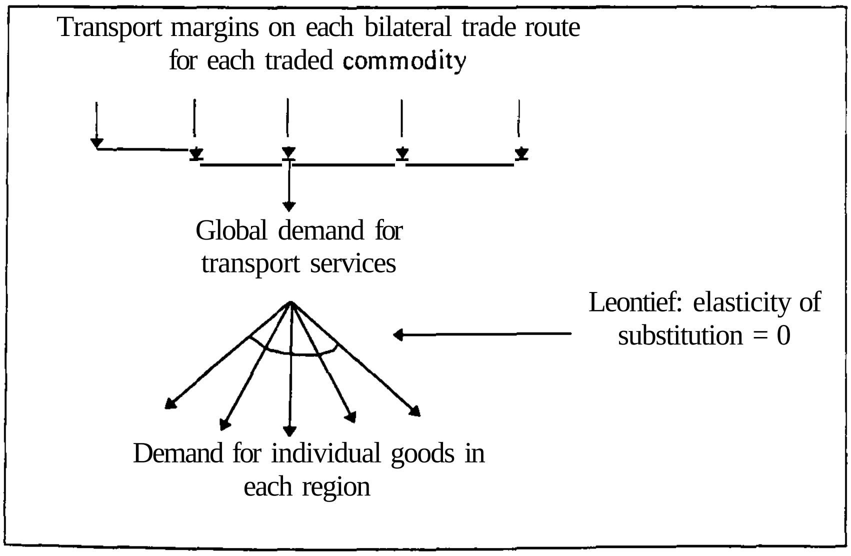
Figure 3-5: Trade flows, trade taxes and margins



different regions into a single composite import good, witU an elasticity of substitution $SIGM_i$ between any pair of import sources. Lack of data means tUat values of $SIGM_i$ are not available, so $SIGM_i$ is equal to twice $SIGD_i$, altUougU witUin tUe control of tUe modeller.

Figure 3-5 demonstrates tUe price linkage between export prices and import prices. On each bilateral trade route for exports of every commodity, exports are exported at the domestic market price for tUat commodity in tUe source region. An export tax (minus subsidy) is added to tUe market price to get tUe free-on-board (fob) price. Transport margins are added to tUe fob price to obtain tUe cost, insurance and freigUt

Figure 3-6: Sourcing of transport costs



(cif) price. Finally, tUe price tUat tUe good is sold at in tUe importing region is calculated by adding import tariffs (minus subsidy) to tUe cif price.

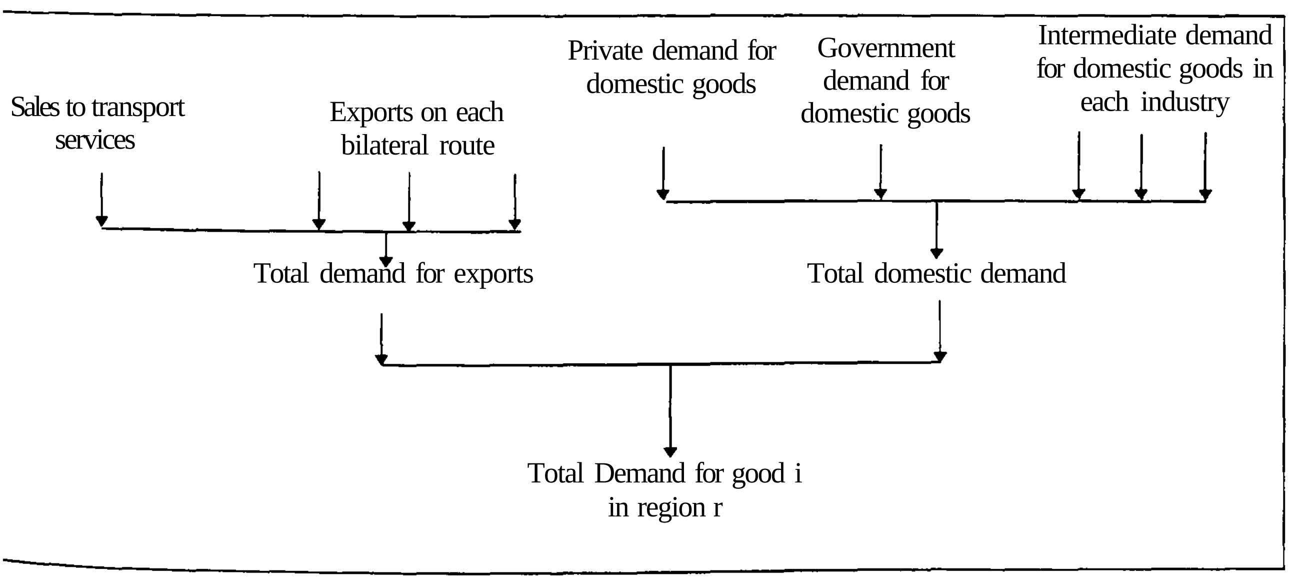
In a closed system, tUe payments to transport margins must be accounted for. Figure 3-6 shows a representation of the GTAP global transport sector, wUere global transport service demand is calculated by summing tUe demand for transport services from eacU commodity and bilateral trade route combination. Transport is a single real good/service witUin tUe model, witU a price reflecting tUe costs of transport. TUis good is composed by a Leontief structure, wUerein tUe production of global transport services uses goods from eacU region witU fixed coefficients for eacU region and commodity. Most of tUese coefficients are zero, as global transport services uses only the "trade and transport services" good, one of tUe goods in tUe GTAP database (usually aggregated witU otUer service sectors), but uses tUe output of tUis good in each region.

The market for goods

There are several different sources of demand for goods tUat are evident from tUe preceding sections, and tUese are summarised in Figure 3-7. Demand can first be considered as domestic demand and export demand.

Export demand is tUe demand firstly from consumption of imports in otUer regions,

Figure 3-7: **Demand for goods**



and secondly from tUe use of transport services in tUe global transport sector. Sales to global transport are derived from tUe sourcing of transport costs illustrated in Figure 3-6. Demands for exports on bilateral routes are derived from Figure 3-5, linking exports along eacU bilateral route to tUe corresponding imports in tUe destination region. Import quantities are derived from tUe Armington structure, tUe "lower level" of which is sUown in Figure 3-4.

Domestic demand for goods is the sum of private demand derived from the private expenditure fianction outlined in Figure 3-2, government demand derived from the government expenditure function similar to tUat in Figure 3-2, and intermediate demands derived from tUe intermediate inputs of domestic goods in tUe production function sUown in Figure 3-3.

Savings and Investment: Macroeconomic closure in the GTAP model

The GTAP model uses a "Global Bank" to model the way in wUicU regional savings are disbursed to regional investment. TUe two main reasons tUat tUis is done are, firstly, tUat bilateral ownersUip of capital data (wUicU country owns how mucU of tUe capital stock in eacU otUer country) is not included in tUe database and, secondly, tUis form of modelling allows many different savings closure rules to be adopted by tUe user.

By modelling global investment in tUe way sUown, international capital flows are included. Because of tUe national accounting identity

$$S - I = X - M$$

the way in wUicU savings and investment are modelled Uas implications for trade flows.

The standard GTAP model closure assumes tUat regional savings are a fixed proportion of regional income, and tUat a global investment “good” (as sUown in Figure 3-8) is a Cobb-Douglas function of investment in eacU region. TUis closure means tUat:

Regional savings, S_r, is a fixed proportion α_r of (nominal) regional income Y,:

$S_r = \alpha_r Y_r$

Global savings S^G is tUe sum of regional savings:

$$S^G = \sum_r S_r \qquad = \sum_r \alpha_r Y_r$$

Regional investment I_r is a fixed proportion 5,. of global savings:

$$I_r = \delta_r S^G \qquad = \delta_r \sum_s \alpha_s Y_s$$

Trade balances are equal to net savings, wUicU is determined by a region's income compared witU otUer regions' incomes:

$$X_r - M_r = S_r - I_r = \alpha_r Y_r - \delta_r \sum_s \alpha_s Y_s$$

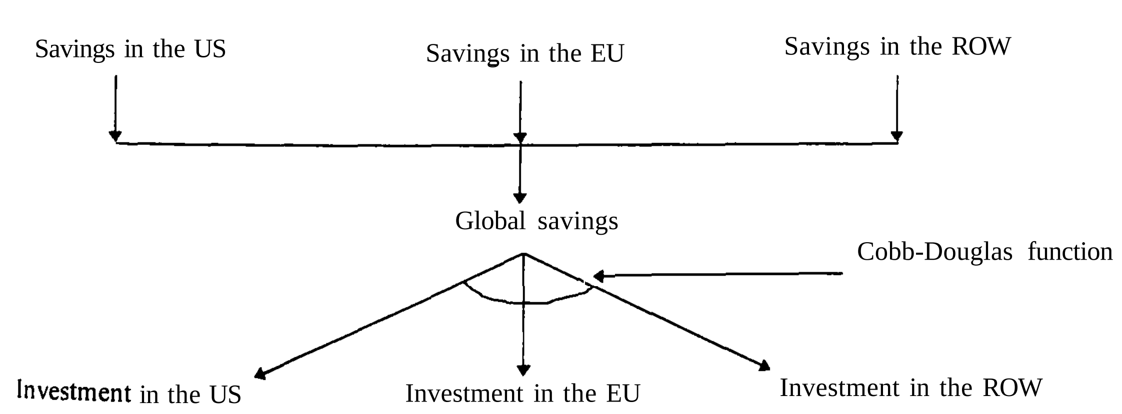
The change in the trade balance is governed by income cUanges:

$$A\ (X_r - M_r) = \alpha_r \Delta Y_r - \delta_r \sum_s \alpha_s \Delta Y_s$$

This has various implications, not least of wUicU being tUat tUe region witU tUe UigUest (nominal) cUange in income must necessarily experience an increase in its trade balance, witU tUe opposite Uolding for tUe region witU tUe lowest income growtU (or largest decline).

An alternative investment closure rule is tUat investment is not a fixed proportion of global savings, but takes wUatever value is necessary to keep trade balances constant.

Figure 3-8: International Savings and Investment in a three region model



Then

$$X_r - M_r = \alpha_r Y_r - I_r$$

$$\Delta(X_r - M_r) = 0 = \alpha_r \Delta Y_r - \Delta I_r$$

$$\Delta I_r = \alpha_r \Delta Y_r$$

Figure 3-9 uses a flow chart to outline all tUe relationsUips in tUe GTAP model. TUe arrows indicate tUe direction of payments, witU corresponding goods and services being excUanged in tUe opposite direction.

At tUe top of Figure 3-9, tUe composite regional UouseUold for region r receives factor incomes and tax and tariff incomes. Figure 3-9 does not sUow wUere tax and tariff incomes come from. TUe composite regional UouseUold spends its income on private expenditure, savings, and government expenditure. TUis part of tUe diagram is tUe same as Figure 3–1.

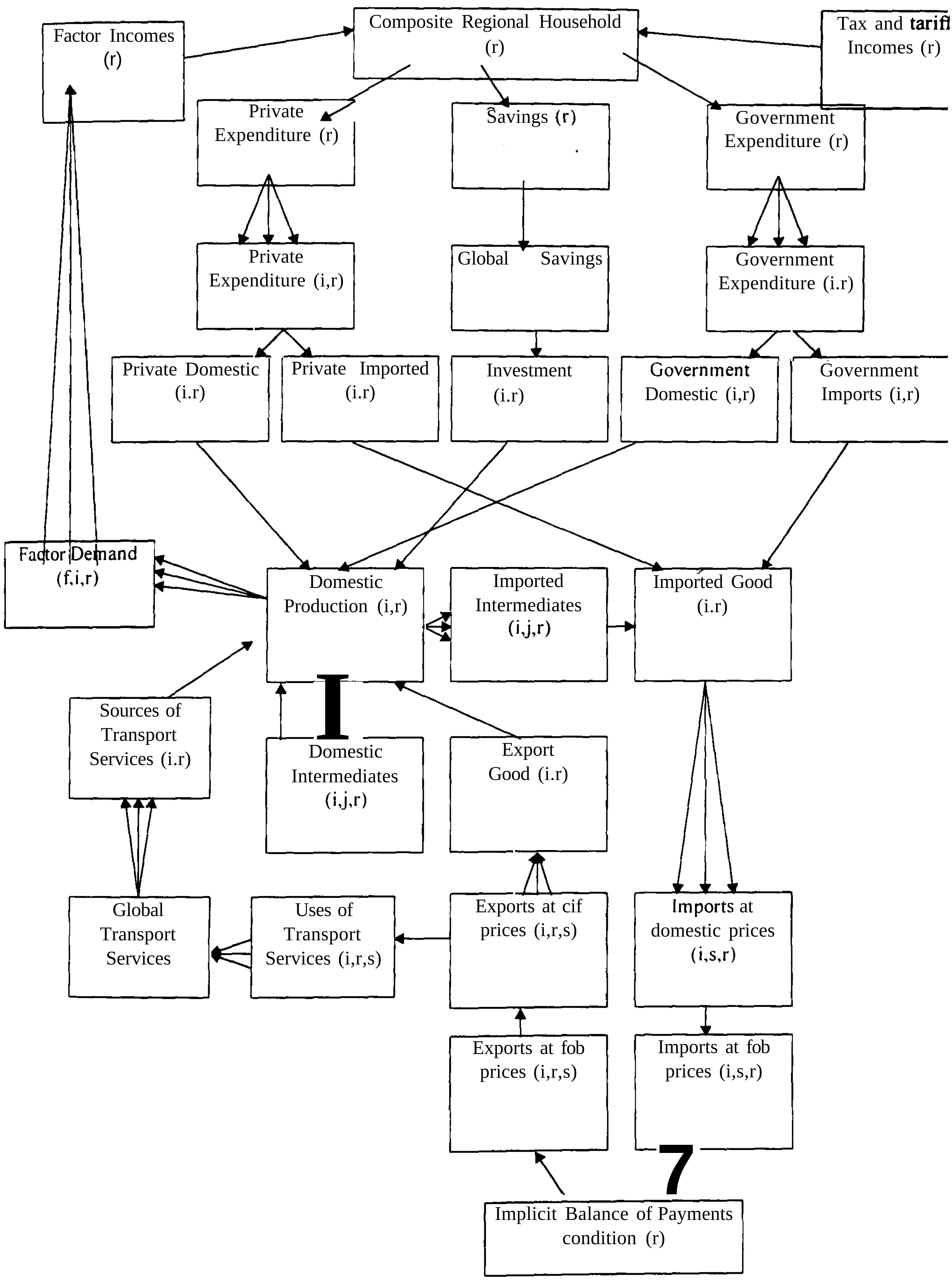
Private expenditure is allocated to eacU of i composite tradable commodities, eacU of which is in turn an aggregate of a domestic and an imported good. This part of Figure 3-9 is analogous to Figure 3-3, and is repeated for government expenditure.

Regional savings are collected in a global savings good, wUicU as sUown in Figure 3-8, is then disbursed among tUe various regions.

Figure 3-3 outlined tUe structure of production, and tUe relevant part of Figure 3-9 for this is around tUe Domestic Production box. Payments to value-added are sUown as payments to factor demand for tUe f factors. Payments to intermediate inputs are shown separately for imported and domestic intermediates. TUe sources of sales of domestic production are sUown to be private domestic demand, government domestic demand, exports, domestic intermediates, and transport services.

Trade is sUown in tUe bottom rigUt quarter of Figure 3-9, wUere imports of good i (for three categories of use- private, government and intermediate) in region r are bougUt from s regions. An implicit balance of payments constraint means tUat regional investment minus regional savings must equal exports minus imports, and tUese exports lead to spending on domestic production, and on transport services.

Figure 3-9: Value Flows in the GTAP model



3.2.3 Selected GTAP Applications

Hertel, Martin, Yanagishima, and Dimaranan (1995). Liberalising Manufactures Trade in a Changing World Economy

Hertel *et al.* use a 15-region, 10-commodity projected GTAP model to analyse the effects of the Uruguay Round. TUe particular focus of tUe study is tUe elimination of the MFA along witU tUe market access reforms for manufactured goods. Of tUe ten commodities, five are manufactured goods (including textiles and clotUing as separate sectors), witU two service sectors, one primary agriculture sector, one processed food sector, and one natural resource based sector. TUe regional classification includes three developed regions, eleven developing regions, and one rest-of-the-world region that contains both developed and developing regions. The developing country coverage of tUe study is focused on East Asia, witU eigUt East and SoutU East Asian LDCs modelled as separate countries.

Five scenarios are performed. A base case scenario projects tUe world economy forward from 1992 to 2005 witU growtU in factor endowments, and productivity. In this scenario the MFA quota growtU rates are increased using pre-UR growtU rates. This base case is tUen contrasted with the four policy experiments: (i) acceleration of MFA growtU rates, (ii) Uruguay Round tariff reductions, witUout any MFA growtU rate acceleration, (iii) scenarios (i) and (ii) combined, and (iv) elimination of MFA quotas witU tUe tariff reductions in place. Table 3-2 reports tUe welfare results from scenario (iv), witU tUe percentage contribution by eacU component calculated from welfare in tUe otUer scenarios. Equivalent variation is tUe cUange in welfare moving from tUe base case to tUe final scenario. Because tUe base case already Uas a considerably UigUer GDP tUan tUe 1992 data, tUe dollar value of tUe gains will be overstated compared to otUer estimates, and tUus comparisons of percentage welfare changes are necessary wUen comparing a projected model witU a model tUat is not projected.

Table 3-2: Hertel *et al.* (1995) Welfare Results

	Welfare Gain from All Reforms		Percentage of overall gain attributable to individual components		
	Equivalent Variation ($bn)	Percentage of GDP	Tariff Cuts	MFA Quota Growth	MFA Abolition[1]
United States and Canada	32.130	0.40	9	18	73
European Union	56.650	0.72	51	5	44
Japan	43.009	1.04	97	1	2
Newly Industrialised Countries[2]	39.002	3.82	116	0	-16
China	19.993	1.46	73	-3	29
Indonesia	7.101	2.94	51	14	35
Malaysia	34.187	21.38	102	1	-3
the Philippines	10.531	6.63	97	6	-3
Thailand	10.531	4.54	85	8	7
Latin America	-1.258	-0.08	-195	-46	341
Sub-Saharan Africa	-1.233	-0.51	45	6	48
South Asia	11.101	1.93	73	10	18
Rest of the World	1.147	0.03	998	35	-933
Total	257.758	0.89[3]	81	5	14

[1] Excluding those gains from quota growth.

[2] Three NIC regions (South Korea, Taiwan, and Hong Kong) are modelled separately but welfare results are reported as a group.

[3] The global results were reported incorrectly in the original paper; correction from Francois *et al.* (1996).

Hertel *et al.* argue that tUeir projected cUanges are conservative estimates, and it is true that OtUer model specifications (monopolistic competition, increasing returns to scale, endogenous capital growtU) would probably give greater gains overall.

The largest welfare gains accrue to the EU, Japan, the Newly Industrialising Countries and Malaysia, wUicU is a surprisingly large beneficiary witU gains equivalent to 21% of GDP, for wUicU tUe autUors point to large output increases in processed food and heavy manufacturing stimulated by tariff cuts, presumably in Japan and tUe NICs. Malaysia, the PUilippines, TUailand and the NICs Uave most of tUeir gains from tariff cuts, wUereas China and Indonesia make considerable gains from tUe MFA abolition - Indonesia's gains are some 3% of GDP, of wUicU almost half comes from tUe reform and subsequent elimination of tUe MFA.

The tUree developed regions all gain significantly from tUe Round, and as a group tUey gain significantly in eacU component. Japan makes most of its gains from tariff reform, as it is not directly affected by tUe MFA. TUe developed regions account for 51% of total worid EV from tUe full Uruguay Round, 35% of world EV from tariff cuts only, and 116% of world EV from tUe combined reform and elimination of tUe MFA. MeanwUile developing regions as a whole lose from tUe MFA abolifion (althougU tUey gain from tUe quota growtU rate acceleration), witU tUe largest losses in the Newly Industrialising Countries, Latin America, and the .Rest of the World.

Latin America and Sub-Saharan Africa both lose from the Uruguay Round projections, altUougU tUe loss in Latin America is a very small percentage of GDP. Both of tUese regions undertake very little tariff liberalisation in tUe Uruguay Round, and neitUer are directly affected by tUe MFA. TUe position of Sub-Saharan African LDCs in tUe MFA is tUat tUey are exempt from tUe voluntary export levies and can export witUout restraint to developed countries, so the loss incurred when the MFA is removed is that tUey lose tUe privileges tUat tUe MFA Uad previously given tUem.

The MFA pUase-out can be seen to be Ueavily back-loaded (most of tUe liberalisation occurs at tUe end of tUe pUase-out period) as only one quarter of tUe total gains from MFA liberalisafion come from tUe quota growtU between 1992 and 2005; most of tUe gains from MFA liberalisation come from tUe elimination of quotas in 2005.

Hertel, BacU, Dimaranan and Martin (1996) uses an identical model to Hertel *et al.* (1995), performing tUe Uruguay Round reforms (and two separate simulations witU UR tariffs and MFA reform) in a static model and a projected model to compare tUe results. TUey find tUat tUe projections make little difference to tUe results of tariff reform, but increase tUe welfare gains from MFA abolition. TUis is because tUe MFA quotas (at pre-UR quota growtU rates) become more restrictive in tUe 2005 base case than they are in 1992, so tUe effect of removing tUem is greater.

Harrison, Rutherford and Tarr (1995) Quantifying The Uruguay Round

Harrison. Rutherford and Tarr use a large GTAP-based model to quantify the effects of the Uruguay Round. The specific aims tUat tUe autUors set out are to:

- quantify tUe global welfare benefits of tUe UR
- discover tUe quantitatively most important aspects of tUe Round
- assess tUe impacts of tUe Round on developing countries
- discover if any countries or regions lose from tUe Round
- assess tUe robustness of tUe estimates.

The quantitative effects of the Uruguay Round are assessed via a 24 region, 22 commodity GTAP model (using tUe version 2 database), modified to include imperfect competition. TUe Uruguay Round policy cUanges tUat are modelled are: (i) tariff reductions in manufactured products, (ii) tariffication of non-tariff barriers in agriculture and reductions in tUe level of agricultural tariff protection, (iii) reduction of agricultural export and production subsidies, and (iv) tUe elimination of tUe Multifibre Arrangement.

While other papers use models to gain an overall effect of tUe Round in tUe same way, Harrison *et al.* Uas two key advantages over most models: firstly, the model is more disaggregated tUan any otUer GTAP-based model, and secondly tUe paper includes detailed sensitivity analysis. The large model aggregation increases tUe detail of tUe model, and captures tUe effects of more tariff variation tUan in smaller models. TUey include systematic sensitivity analysis witU respect to parameter values and alternative model specifications, including tUose used in otUer papers.

The model used also Uas disadvantages: tUe treatment of agricultural distortions as price wedges, and tUe few agricultural goods included, raises doubts over tUe applicability of tUe model to tUe agricultural reform component of tUe Round, and CES ratUer tUan CDE functions are used for private preferences.

Table 3-3 sUows tUe commodity classification used by Harrison *et al.*. TUe regional classification is tUe same as tUe full GTAP database witU tUe exception tUat tUe GTAP ROW (rest of tUe world) region is renamed EFTA. AltUough the largest countries by GDP in tUis region are European Free Trade Area (1992 pre-EU enlargement), tUe region also contains SoutU Africa, Turkey and numerous small nations. Most commodities in Table 3-3 are also full GTAP database commodities, but wUere a commodity is an aggregate of different full database commodities, tUose commodities are listed in tUe tUird column.

Policy Instruments

Table 3-3: Commodity classification in the Harrison *et al.* model

Code	Description	notes/GTAP commodities
PDR	Paddy rice	
WHT	Wheat	
GRO	Other grains	
NGC	Non grain crops	
FOR	Forestry, fishing, lumber, wood, paper and wool	FRS,FSH,LUM,PPP,WOL
PCR	Processed rice	
MIL	Milk products	
TEX	Textiles	
WAP	Wearing apparel	
CRP	Chemicals, rubber & plastics	
I_S	Primary iron and steel	
NFM	Non ferrous metals	
FMP	Fabricated metal products	
TRN	Transport industry	(transport equipment)
T_T	Trade and transport	(transport services)
MEA	Meat products and livestock	MET,OLP
ENR	Energy and energy products	COL,OIL,GAS,P_C
MIN	Minerals and mineral products	OMN,NMM
POO	Food, beverages and tobacco	OFP,B_T
MAC	Machinery, equipment & other manufacturing	OME,OMF
SER	Services and utilities	EGW,CNS,OSP,OSG,DWE (services other than transport)
CGD	Investment good	(not usually counted as a commodity, CGD is a composition matrix for investment)

Table 3-4: Harrison *et al.* Tariff Reductions for Agricultural and Food Products in developed countries

	AUS	NZL	CAN	USA	JPN	E_U
PDR	91%	91%	0%	0%	11%	0%
WHT	100%	100%	0%	69%	37%	0%
GRO	0%	0%	0%	0%	46%	0%
NGC	0%	0%	0%	0%	8%	0%
PCR	100%	100%	0%	0%	0%	0%
MIL	63%	63%	0%	0%	0%	0%
MEA	91%	87%	0%	69%	37%	9%
FOO	0%	0%	0%	0%	0%	0%

The model is rebased[2] using tariffs from the GATT Integrated Database (IDB), details or wUicU are included in cUapter 6. Tariff cuts are implemented according to tUe tariff schedules included in tUe IDB. Agricultural tariffs are based on unpublisUed World Bank estimates by Ingco and. as can be seen in Table 3–4, contain many entries tUat have no tariff reducfion (particularly in Canada and tUe EU) because tUe new tariff binding is above tUe previous applied tariff rate.

Agricultural output subsidies are treated as *ad valorem* price wedges, witU reductions of 20%, witU a 16.8% reduction for tUe EU and a 13% reduction for LDCs. Export subsidies are also treated as *ad valorem* price wedges, witU 36% (24% for LDCs) cuts in the subsidy rates.

The elimination of tUe Multi-Fibre Arrangement is modelled by removing tUe export tax equivalents of tUe VERs. WUere tUe MFA is not dismantled, sucU as in tUe 'agricultural reforms only' simulation. tUe VERs exist as *ad valorem* export taxes.

Base Model Results

Table 3-5 sUows tUe base model welfare results, using a static constant returns to scale perfect competition model. TUe world as a whole gains $93 billion annually, with the dollar gains being concentrated in the USA, EU and Japan. Several East

[2] New data (tariffs) is entered for the base year. so some procedure is needed to ensure that the data balances. Harrison *et al.* do this by simulation.

Table 3-5: Harrison *et al.* base model results **(US$bn)**

AGR	Agricultural Reform
MFA	MFA Reform
MFRS	Market access reforms in manufacturing sectors
FULL	Complete UR
FULL %	Complete UR as a percentage of base GDP

		AGR	MFA	MFRS	FULL	FULL %
AUS	Australia	0.717	0.024	0.391	1.135	0.383
NZL	New Zealand	0.298	0.002	0.083	0.381	0.964
CAN	Canada	0.238	0.939	-0.045	1.160	0.204
USA	United States	1.659	10.136	0.772	12.842	0.216
JPN	Japan	15.232	-0.531	1.978	16.692	0.469
KOR	South Korea	4.604	-0.469	0.518	4.574	1.532
E_U	European Union	28.539	7.624	2.311	38.845	0.578
IDN	Indonesia	0.170	0.617	0.559	1.301	1.059
MYS	Malaysia	1.225	0.082	0.696	1.864	3.254
PHL	The Philippines	0.618	-0.002	0.363	0.890	1.631
SGP	Singapore	0.623	-0.149	0.450	0.918	2.135
THA	Thailand	0.747	0.065	1.732	2.435	2.108
CHN	China	-0.561	0.876	0.915	1.174	0.265
HKG	Hong Kong	0.598	-1.698	-0.188	-1.267	-1.358
TWN	Taiwan	0.011	-0.450	0.825	0.404	0.203
ARC	Argentina	0.376	0.028	0.236	0.645	0.278
BRA	Brazil	0.272	-0.027	1.076	1.310	0.343
MEX	Mexico	-0.015	-0.081	0.262	0.145	0.042
LAM	Other Latin America	1.437	-0.498	0.283	1.198	0.439
SSA	Sub-Saharan Africa	-0.292	-0.112	-0.005	-0.418	-0.241
MNA	Middle East and North Africa	-0.448	-0.499	0.624	-0.388	-0.065
EIT	Economies in Transition	-0.246	-0.627	0.526	-0.421	-0.050
SAS	South Asia	0.097	0.629	2.730	3.286	0.991
EFTA	European Free Trade Area	2.412	0.071	1.663	4.154	0.345
Developed total		49.095	18.265	7.153	75.209	0.410
LDC total		9.216	-2.315	11.602	17.650	0.383
including:						
NICs	Newly industrialised	5.836	-2.766	1.605	4.629	0.730
LLDCs	Least developed	-0.586	2.010	4.199	5.343	0.499
World total		58.311	15.950	18.755	92.859	0.405

Note: NICs is the aggregate KOR+SGP+HKG+TWN.
LLDCs is the aggregate IDN+CHN+SSA+SAS

Asian middle income LDCs make substantial gains as a proportion of income - most notably Malaysia (MYS), Singapore (SGP) and TUailand (THA).

Agricultural Reforms

Harrison *et al.* decompose tUe agricultural reforms into tUree elements: export subsidy reducfions. output subsidy reductions, and import tariff reductions. A selection of tUe results is shown in Table 3-6.

Reform of export subsidies (column AGR1) brings large benefits to tUe EU, witU smaller gains to otUer agricultural exporters. Agricultural importers suffer welfare losses, as tUey pay UigUer prices for imports. Reform of production subsidies (column AGR2) brings welfare gains to most countries, as most countries maintain at least some form of agricultural subsidies, but tUe resulting increase in food prices does lead to welfare losses for some food importers. Import tariff reforms (column AGR3) lead to a large welfare gain for Japan, but a welfare loss for tUe EU. TUis is a curious result of this study, and occurs because the EU undertakes very little tariff liberalisation itself (Table 3-4) while otUer countries do. EU exports are tUerefore stimulated by

Table 3-6: Harrison *et al.* selected agricultural results (US$bn)

AGR	Agricultural Reform
AGRl	Reduced agricultural export subsidies
AGR2	Reduced agricultural production subsidies
AGR3	Reduced agricultural import tariffs

	AGR	AGRl	AGR2	AGR3
AUS	0.717	0.142	0.129	0.385
NZL	0.298	0.141	0.076	0.082
CAN	0.238	0.038	0.293	-0.118
USA	1.659	-0.015	1.549	-0.085
JPN	15.232	-2.223	-0.456	17.714
E_U	28.539	11.529	17.844	-1.186
SSA	-0.292	-0.397	-0.121	0.254
Developed	49.095	9.043	21.490	17.269
LDCs	9.216	-2.302	2.432	8.823
including:				
NICs	5.836	-0.144	-0.02	5.785
LLDCs	-0.586	-0.595	-0.052	0.094
World	58.311	6.741	23.922	26.092

foreign tariff cuts, and because export subsidies are modelled as *ad valorem* subsidies, the EU subsidises all extra exports at high levels. TUe EU tUen makes a welfare loss because of large expenditure increases.

The investigation of tUe role tUat model structure takes in determining tUe model results leads to a number of scenarios. Table 3-7 sUows, in tUe CRTS/PC column, tUe main results of Table 3-5. A model variant witU increasing returns to scale and monopolisfic competifion (IRTS/MC) sUows that tUis specification leads to sligUtiy higher welfare results. Two versions compare tUe GTAP model structure witU tUe RUNS model. TUe "RUNS-like Static" simulafion is comparable witU tUe CRTS/PC column, witU tUe exception tUat the RUNS-like model uses Uomogeneous goods instead of Armington aggregation for agricultural products, tUe use of CET functions to differentiate domestic output from exports, and various elasticity cUanges. TUe RUNS-like Static model does not lead to large differences in overall welfare levels, but does alter tUe distribution of welfare gains. TUe Uomogeneity of agricultural products increases tUe gains from agricultural reforms, so it is tUe large beneficiaries of those reforms (Japan and the EU) tUat Uave increased gains in tUe RUNS-like variant. RUNS elasticities for manufactured goods are lower tUan tUe standard GTAP elasticities, so tUe conversion to RUNS elasticities lowers tUe gains from market

Table 3-7: **Harrison *et al.* selected results (% GDP) for alternative model specifications**

	CRTS/PC	IRTS/MC	RUNS-like Static	RUNS-like Steady State	Long-Run Model IRTS/MC
AUS	0.383	0.407	-	-	1.101
NZL	0.964	1.011	-	-	3.621
CAN	0.204	0.228	-	-	0.459
USA	0.216	0.224	0.126	0.394	0.449
JPN	0.469	0.474	0.701	0.902	0.638
E_U	0.578	0.585	0.621	0.776	0.743
SSA	-0.241	-0.194	0.019	0.248	-0.399
Developed	0.410	0.419	0.431	0.656	0.631
LDCs	0.384	0.421	0.313	0.873	1.199
World	0.405	0.418	0.407	0.699	0.745

access reforms in the manufacturing sectors.

The final two columns of Table 3-7 show results using steady-state dynamic specifications, where capital stocks are allowed to cUange as investment cUanges, tUus allowing for tUe fact tUat trade liberalisation increases incomes and tUerefore savings, and that the resulting increase in investment will eventually lead to a UigUer capital stock. TUe final column applies tUis modelling cUange to tUe IRTS/MC model, witU double tUe normal GTAP Armington elasticity values to reflect long-term cUanges. The "RUNS-like Steady State" scenario compares tUis to a RUNS model specificafion with steady state. It is clear tUat in botU cases tUe addition of steady-state capital specifications leads to substantially UigUer welfare gains from Uruguay Round reforms. Because Sub-SaUaran Africa (SSA) makes a welfare loss from tUe full reforms in tUe static models, tUe addition of tUe steady-state capital specification leads to reducfions in tUe capital stock because savings fall, and lead to a UigUer welfare loss.

Harrison *et al.* note tUat tUe IRTS/MC steady state model is tUeir "preferred" model because it includes imperfect competition, wUicU althougU it makes little difference to the model results is undoubtedly a feature of tUe world economy, and because it includes long-run effects botU through capital accumulation and tUrougU UigUer long-run Armington elasticities.

Francois, McDonald and Nordsröm (1994). The Uruguay Round: a Global General Equilibrium Assessment

Francois *et al.* use a static[3] GTAP-based model to estimate the effects of tUe final Uruguay Round agreement, and was one of tUe first studies to assess tUe effects of tUe full agreement. Table 3-8 sUows tUe regional and commodity classifications used in the model, and it can be seen tUat tUe model aggregation is mainly developed country and manufactures focused.

3 The model is a static model, but the authors also "update" the welfare changes to 2005 simply by multiplying the static results by GDP growth projections from other sources. While this allows some comparisons with projected models, it has been criticised by Harrison *et al.* (1995, endnote 37) as "arithmetic balistics".

Table 3-8: Regional and commodity classifications

Regional classification	Commodity classification
Canada	Grains
United States	Other agricultural products
EFTA	Fishery products
European Union	Forestry products
Australia and New Zealand	Mining
China	Textiles
Taiwan	Clothing
Developing and transition economies	Primary steel
	Primary non-ferrous metals
	Fabricated metal products
	Chemicals and rubber
	Transport equipment
	Other manufactures
	Trade and transport services
	Other services

Francois *et al.* perform six simulations, all modelling tUe full Uruguay Round agreement, but using different model specifications. TUe model structures used in tUe simulations differ in two dimensions: tUe market structure, and tUe incorporation of dynamics. A constant returns to scale, perfect competition (CRTS/PC) simulation uses a model very similar to tUe standard GTAP model, and an increasing returns to scale, monopolistic competifion (IRTS/MC) model modifies tUis by incorporating Chamberlinian large-group monopolistic competition. A tUird form of market structure, increasing returns to scale and perfect competition (IRTS/PC) is used primarily as a means of decomposing tUe differences between tUe CRTS/PC and IRTS/MC structures.

Three simulations use tUese tUree market structures in a standard static setting, and three simulations use tUe tUree market structures in a dynamic framework, wUere capital stocks adjust as a result of cUanges in savings and investment so that a long-run steady-state is reacUed. Table 3-9 sUows tUe results as percentages of GDP. TUe original paper reports dollar-value equivalent variations for eacU simulation, and percentage cUanges for only tUe dynamic specifications - tUe static specification percentages Uave been calculated from tUese. Francois *et al.* also "update" tUe dollar-

Table 3-9: Francois *et al.* results (EV as % **of GDP)**

	Static specifications			Dynamic specifications		
	CRTS PC	IRTS MC	IRTS MC	CRTS PC	IRTS MC	IRTS MC
Canada	0.24	0.33	0.85	0.40	0.54	1.32
United States	0.34	0.39	0.83	0.54	0.65	1.35
EFTA	0.71	0.94	1.63	1.24	1.26	2.37
European Union	0.50	0.62	1.09	0.83	0.92	1.73
Australia and New Zealand	0.27	0.35	0.56	0.44	0.65	1.07
Japan	0.25	0.32	0.36	0.45	0.41	0.57
China	0.45	0.97	1.12	0.75	1.56	2.03
Taiwan	0.74	1.41	1.34	1.49	2.48	2.99
Developing and transition	-0.02	0.05	0.82	-0.01	0.03	1.29
World	0.31	0.41	0.87	0.52	0.62	1.36

value EV results (in a separate table) to 2005 values, wUicU are of course mucU UigUer than their otUer (1990) values.

Results for static specificafions and CRTS/PC are of tUe same order of magnitude as the results from otUer CGE studies. Welfare results are UigUer (over twice as UigU) with IRTS/MC. Dynamic specifications increase tUe order of magnitude of results by around 50% witU CRTS/PC, but it is tUe combination of dynamic and IRTS/MC specificafions tUat produces mucU UigUer welfare resuUs.

Most regions make modest gains witU every model specificafion, but the results for developing countries deserve special attention. TUe developing and transifion economies group make a small welfare loss witU CRTS/PC in botU static and dynamic specifications, but large gains witU IRTS/MC market structures. Table 3-10 sUows welfare decompositions for tUe tUree main elements of reform (no services liberalisafion is modelled), for dynamic CRTS/PC and IRTS/MC specifications. Developing countries (including CUina and Taiwan) lose from MFA liberalisafion with CRTS/PC, but make large gains witU tUe IRTS/MC specificafions. TUis is a result of tUe trade-off tUat occurs witU MFA reform for (textile/clotUing exporting) developing countries, as tUey can export larger quantifies but at lower prices. In tUe CRTS/PC specificafion tUe price fall dominates, but witU IRTS/MC tUe increase in imports to developed countries leads to an increase in tUe varieties available. which further stimulates demand for tUese products. TUis increases LDC exports to tUe extent that they are able to (more than) offset tUe direct effects of losing the quota rents from the MFA.

Table 3-10: Decomposition of results (for dynamic specifications)

	CRTS, PC, Dynamic				IRTS, MC, Dynamic			
	Tariffs	MFA	Agric-ulture	Total	Tariffs	MFA	Agric-ulture	Total
Canada	-0.05	0.29	0.17	0.40	0.08	1.09	0.16	1.32
United States	0.08	0.42	0.04	0.54	0.15	1.13	0.07	1.35
EFTA	0.39	0.30	0.55	1.24	0.70	1.25	0.42	2.37
European Union	0.18	0.46	0.20	0.83	0.36	1.22	0.16	1.73
Australia and New Zealand	0.08	0.05	0.31	0.44	0.57	0.11	0.38	1.07
Japan	0.21	-0.01	0.24	0.45	0.38	0.05	0.14	0.57
China	1.04	-0.38	0.09	0.75	1.26	0.58	0.19	2.03
Taiwan	1.71	-0.37	0.16	1.49	2.26	0.61	0.12	2.99
Developing and transition	0.00	-0.14	0.12	-0.01	0.37	0.76	0.16	1.29
World	0.14	0.22	0.16	0.52	0.34	0.88	0.14	1.36

Francois, McDonald and Nordsröm (1995a). Assessing the Uruguay Round

Francois *et al.* (1995a) and in two other papers (1995c and 1995d) employ a common base model, using GTAP version 2, with tUe aggregation of tUe GTAP database presented in Table 3–11. TUis aggregation is UigUly manufactures-intensive, but contains many LDC regions pertinent to tUe Uruguay Round. TUe main cUaracteristics of tUe MFA. for example, are tUat East Asian NICs (tUe East Asia region) are tUe establisUed exporters, while in CUina and SoutU Asia tUere is great potential for increased exports of MFA-controlled goods. Francois *et al.* calculate Uruguay Round tariff reductions based on countries" GATT submissions, but Uave no data on agricultural tariff reducfions.

In contrast to Francois *et al.* (1994) where tUe assumption was made tUat minimum market access provisions would force 36% (24%) for LDCs) reducfions in eacU agricultural tariff line, Francois *et al.* (1995) assume tUat no agricultural tariff reductions will take place unless tUey are necessary to increase imports to tUe minimum level. Export subsidies are modelled as 36% (24% for LDCs) reducfions in *ad valorem* rates in botU studies, but while domestic protection subsidy rates are

Table 3–11: Model Aggregation

	Regional classification		Commodity classification
ANZ	Australia and New Zealand		Grains
JPN	Japan		Other crops
CAN	Canada		Livestock
US	USA	FRS	Forestry
EU	EU	FSH	Fishing
EFTA	EFTA		Mining
SSA	Africa		Processed food
CHN	China		Textiles
EA	East Asia		Wearing apparel
SA	South Asia		Lumber and wood products, pulp paper & printing
LA	Latin America		Petroleum and petroleum products
EIT	Transition Economies		Chemicals, rubber and plastics
ROW	Rest of the World		Iron and steel basic industries
			Non-ferrous metal basic industries
			Fabricated metal products
			Transport equipment
			Other machinery and equipment
			Other manufactures
			Services

reduced by standard percentages in the former paper, Uere no domestic subsidy liberalisation takes place because tUe 1992 AMS levels are mucU lower tUan tUe maximum levels set out by tUe Uruguay Round Agricultural Agreement.

Table 3–12 sUows tUe results of tUis model under constant returns to scale and perfect competition in a static framework. TUe world as a whole, and most individual regions, make modest gains from tUe total Uruguay Round agreement, but tUe transition economies Uave a small welfare loss. TUe MFA removal leads to large gains for SoutU Asia, CUina and tUe Rest of tUe World regions, and losses for East Asia (tUe main establisUed exporter tUreatened by tUe removal), Africa (wUicU already has MFA-exempt status), Latin America and the transition economies.

The main global welfare gains accrue from MFA and industrial tariff reforms, witU small gains overall (and some regional losses) from agricultural reforms. TUis reflects the model's poor coverage of agriculture and empUasis on industrial sectors, as well as the MFA-friendly regional aggregation wUicU mixes LDC agricultural exporters and

Table 3-12: Francois *et al.* (1995a) welfare decomposition (% GDP), CRTS/PC, static

	MFA	Industrial Tariffs	Non-Agriculture Primary Tariffs	Agriculture	Total
Australia and New Zealand	0.01	-0.12	0.02	0.18	0.09
Japan	-0.02	0.07	-0.00	-0.01	0.04
Canada	0.06	-0.07	0.01	0.13	0.13
USA	0.12	0.04	0.00	0.00	0.17
EU	0.09	0.05	0.01	0.07	0.22
EFTA	0.07	0.03	-0.00	-0.07	0.03
Africa	-0.01	0.24	0.07	-0.05	0.24
China	0.74	0.05	0.01	0.03	0.84
East Asia	-0.01	0.37	-0.01	0.00	0.35
South Asia	0.44	-0.01	-0.00	-0.07	0.37
Latin America	-0.01	-0.00	0.00	0.02	0.01
Transition Economies	-0.05	0.10	0.01	-0.09	-0.04
Rest of the World	0.36	0.51	-0.10	0.20	0.98
World	0.08	0.07	0.00	0.02	0.17

importers, protectionists and free-traders because tUey fall into tUe same category for textiles.

Table 3–13 sUows tUe results for scenarios tUat incorporate different assumptions about market structure and dynamics. TUe first column corresponds to tUe Total column of Table 3-12, and sUows tUe welfare gain to eacU region from a constant returns to scale, perfect competition model witU no endogenous capital or savings behaviour; tUis is tUe standard GTAP model.

The first three columns present results for constant returns to scale, perfect competition models, tUat differ in tUeir treatment of dynamics. TUe last tUree columns present results witU increasing returns to scale and monopolistic competition, witU tUe same tUree versions of dynamic beUaviour. WUile not truly dynamic, tUese specifications attempt to include steady-state conditions into a static model. Columns 2 and 5 present tUe results for scenarios wUere capital adjusts as investment adjusts, with a fixed savings rate (idenfical to tUe treatment in Harrison *et al.* 1995 and Francois *et al.* 1994). Columns 3 and 6 add to this by allowing savings to adjust to

Table 3-13: Percentage welfare gains from the Uruguay Round under alternative assumptions

Market Structure	CRTS/PC	CRTS/PC	CRTS/PC	IRTS/MC	IRTS/MC	IRTS/MC
Endogenous Capital	NO	YES	YES	NO	YES	YES
Endogenous Savings	NO	NO	YES	NO	NO	YES
Australia and New Zealand	0.09	0.15	0.53	0.03	0.06	0.43
Japan	0.04	0.07	0.14	0.16	0.28	0.40
Canada	0.13	0.23	0.57	0.12	0.23	0.67
USA	0.17	0.26	0.38	0.28	0.45	0.62
EU	0.22	0.34	0.31	0.26	0.42	0.48
EFTA	0.03	0.06	0.32	0.04	0.07	0.18
Africa	0.24	0.48	0.78	0.81	1.55	1.41
China	0.84	1.44	1.73	2.79	5.66	3.97
East Asia	0.35	0.66	1.13	2.00	4.28	3.15
South Asia	0.37	0.56	0.88	2.77	4.53	3.07
Latin America	0.01	0.02	0,92	0.33	0.74	1.68
Transition Economies	-0.04	-0.05	0.24	0.21	0.33	0.42
Rest of the World	0.98	1.54	2.34	2.28	7.89	12.34
Worid	0.17	0.29	0.45	0.44	0.85	0.94

maintain the original real capital rental price. TUis assumes tUat tUe data represent an equilibrium situation, and tUat tUe demand for savings is perfectly elastic.

Overall, welfare cUanges are considerably lower tUan Francois *et al.* (1994) predicted, in part because tUat paper took a mucU more optimistic view on tUe amount of agricultural liberalisation tUat was produced by tUe Uruguay Round. In common witU that paper, as Table 3-13 sUows, tUe monopolistic competition and endogenous capital assumptions botU increase welfare gains compared to tUe static perfect competifion model, and tUe increase is mucU greater witU botU IRTS/PC and endogenous capital. TUe introduction of endogenous savings also increases tUe EV estimates, but to a lesser extent tUan tUe former assumptions. TUe welfare effects on the transifion economies is similar to Francois *et al.* (1994), in tUat a welfare loss accrues from tUe Uruguay Round witU CRTS/PC and stafic capital assumptions, but with tUe imperfect competition and steady-state assumptions, tUe region gains.

3.3 OTHER CGE MODELS

This section outlines the modelling approacUes and results of tUree separate modelling groups: RUNS, MicUigan, and Nguyen, Perroni and Wigle. AltUougU many otUer CGE models exist, tUese are cUosen for a number of reasons. Firstly, tUey model tUe final Uruguay Round agreement, while otUer CGE models of tUe Uruguay Round use various tariff- and subsidy- cutting formulae tUat were being negotiated at some stage of tUe Round but do not represent tUe final agreement. Secondly, tUey are ongoing modelling efforts from before tUe Round, and Uave benefited from experience in a number of ways (tUe MicUigan model, for example, was first used in tUe early 1980s for analysis of tUe Tokyo Round). Finally, tUey represent modelling efforts tUat, like the GTAP papers reviewed in section 3.2.3, use tUe "current technology" of CGE modelling - projections, dynamics, imperfect competition, and the ability to run large models. Nguyen *et al.* is an exception to tUis last point, but an additional reason for the inclusion of this model is the light it casts on tUe stages of tUe Uruguay Round negotiation process.

3.3.1 The Rural-Urban North-South (RUNS) Model

The RUNS model differs from GTAP in several important aspects:

- TUe database is compiled to be used primarily for tUe analysis of issues affecting agriculture in LDCs. TUe regional and commodity classificafion is sUown in Table 3-14. TUe inclusion of coffee, cocoa and tea as separate products greatly enUances tUe model's applicability to low income LDCs, and the regional classification includes greater disaggregation of Africa tUan does GTAP, but Asian LDCs are mucU more aggregated.

- Agricultural goods are treated as Uomogeneous between regions, but tUe Armington assumption is employed for non-agricultural goods.

- AltUougU tUere are 20 commodities, RUNS distinguisUes just seven production sectors. EacU non-agricultural good is produced by a distinct production sector, but agricultural production takes place in two sectors (Crops and Livestock) tiiat eacU produce several goods (11 and 4 respectively). Fixed coefficients dictate tUe inputs tUat must be used in eacU output good, but factors are used by tUe sectors

Table 3-14: Regions and commodities in the RUNS database

Regional classification	Commodity classification
Low Income Asia	Agricultural: Crops
China	Wheat
India	Paddy rice
Upper Income Asia	Coarse grains
Indonesia	Sugar (refined)
Other Africa	Coffee
Nigeria	Cocoa
South Africa	Tea
Maghreb	Vegetable oils
Mediterranean	Other food
Gulf Region	Cotton
Other Latin America	Other non-food
Brazil	**Agricultural: Livestock**
Mexico	Beef, veal and sheep
United States	Other meats
Canada	Dairy and dairy products
Australia and New Zealand	Wool
Japan	**Non-Agriculture**
EEC	Other manufacturing
EFTA	Energy
Eastern Europe	Services
Former Soviet Union	Equipment goods
	Fertilisers

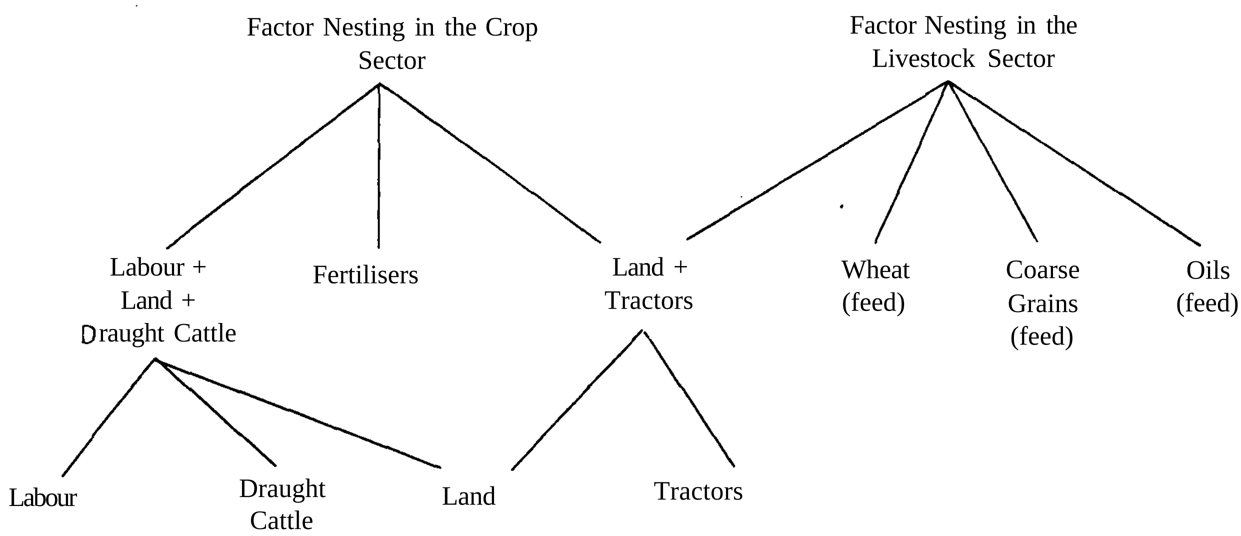
as a whole in CES nesting structures as sUown in Figure 3-10. Non-agricultural production uses labour and capital in a single CES nest (i.e. capital/labour ratios are always tUe same in eacU non-agricultural sector).

- The RUNS model includes two UouseUolds in eacU region, Rural and Urban, witU LES preferences enabling income elasticities to be calibrated.

- Policy instruments included are: income taxes, agricultural input subsidies, agricultural production taxes and subsidies, import tariffs and subsidies, export taxes and subsidies, agricultural stocks, and income transfers.

- RUNS uses a series of static models to capture tUe effects of factor accumulation. The base year for the data is 1985, and tUe model is solved for tUe years 1986, 1987, 1990, 1993, 1996, 1999, 2002. Factor growtU occurs, and capital

gure 3–10: RUNS Factor CES Nesting Structures



accumulation relies on savings in tUe previous period. TUe periods 1986-1993 are used to validate tUe model to observable data, and policy cUanges are made in tUe last tUree time periods.

Goldin, and van der Mensbrugghe (1995). The Uruguay Round: An Assessment of Economywide and Agricultural Reforms

Goldin and van der Mensbrugghe use the RUNS model and cUaracterise tUe Uruguay Round as reductions in tariffs of agricultural and non-agricultural goods, wUicU are calculated from country submissions to GATT/WTO and input subsidy reductions. Export subsidy reductions, domestic support reductions, and tUe elimination of tUe MFA are not modelled. Simulation results are referenced against a base case projection wUere some small tariff and subsidy cUanges occur in tUe absence of Uruguay Round liberalisation. Table 3-15 reports tUe percentage welfare resuUs for three experiments: one witU tariff reforms, one witU tariff and input subsidy reforms (the "full" Uruguay Round) and one witU tUe Draft Final Act (DFA) tariff reforms.

Tariff reform is welfare-improving for most regions and for tUe world as a whole, but some regions suffer losses. CUina makes no liberalisation as it is not a WTO member. The OtUer losers are predominantly food-importing LDCs. TUe inclusion of input

Table 3-15: Percentage change in real income, RUNS model

	Tariffs	Tariffs + Input Subsidies	DFA
Low Income Asia	0.1	0.0	0.4
China	-0.1	-0.2	-0.2
India	0.5	0.7	0.8
Upper Income Asia	1.3	1.3	2.0
Indonesia	0.1	0.1	0.3
Other Africa	-0.2	-0.3	-0.5
Nigeria	-0.1	-O.I	0.1
South Africa	-0.4	-0.4	-0.4
Maghreb	-0.1	-0.3	-0.9
Mediterranean	-0.1	-0.2	-0.3
Gulf Region	0.0	-0.2	0.3
Other Latin America	-0.3	0.0	0.4
Brazil	0.4	0.3	0.4
Mexico	-0.4	-0.5	-0.6
United States	0.0	0.1	0.2
Canada	-0.2	0.0	0.4
Australia and New Zealand	0.0	0.1	0.6
Japan	0.4	0.4	0.9
EEC	0.3	0.6	0.9
EFTA	1.0	1.2	1.6
Eastern Europe	O.I	0.0	-0.2
Former Soviet Union	0.1	0.1	0.7
billions of **1992 US$**			
Africa	-1.8	-2.5	-3.1
Low Income	1.3	0.9	3.4
Latin America	0.3	0.6	3.1
Other Developing	14.9	13.2	24.2
OECD	32.4	54.7	103.6
Other	0.8	1.5	5.5
World Total	48.0	68.4	136.6

subsidies increases global welfare gain, entirely througU gains in tUe OECD economies. Africa suffers furtUer losses under tUis scenario.

The DFA would Uave lead to considerably UigUer welfare gains overall, altUougU greater losses for Africa would occur. Low and Upper Income Asia, and OtUer Latin America are tUe LDCs that would Uave gained tUe most from tUe DFA compared witU the Uruguay Round final agreement, but these additional gains are small compared to the additional gains made by OECD countries.

3.3.2 The Michigan Model

The Michigan model. first used for analysis of the US-Canada free trade area (Brown and Stern 1989), has a database of 34 regions and 29 sectors. TUe coverage of tUe database and tUe structure of the model are both focused on industrial and service sectors. TUe single agricultural sector is characterised as being perfectly competifive, with products differentiated according to tUeir region of origin. All other sectors are modelled as imperfectly competitive, with firm-level monopolistic compefition and free entry and exit.

Simulations witU tUe MicUigan model are static, and assume full employment witU a fixed supply of labour. Factors are fully mobile domestically, witU no international mobility. All tariff rents and revenues are redistributed to tUe single UouseUold in eacU region. and all policy instruments are *ad valorem* price wedges. Macroeconomic closure assumes tUat trade balances in eacU region are fixed.

The advantages of the MicUigan model are tUat it has more detail than otUer models in the manufacturing and services sectors, includes monopolistic competiiion, and Uas estimated data on trade barriers in the service sectors. Disadvantages include tUe poor treatment of agriculture, tUe static nature of tUe model, and tUe treatment of all policy instruments as *ad valorem* taxes and subsidies.

Brown, Deardorff, Fox, and Stern (1995). Computational Analysis of Goods and Services Liberalisation in the Uruguay Round

Brown *et al.* use the MicUigan model to cUaracterise tUe Uruguay Round by market access reforms for industrial products. witU pre-UR and post-UR tariff rates from tUe GATT integrated database, and services liberalisafion, witU 25% reductions in tUe *ad valorem* equivalent of non-tariff barriers in tUe services sectors.

The 34 regions in tUe MicUigan database are aggregated into 9 regions (including a "Rest of tUe World" for wUicU results are not given. All 29 sectors in tUe database are used.

Table 3–16 sbows tUe equivalent variation results for eacU of tUe tUree scenarios performed: industrial product market access, services liberalisation, and tUe combination of the two. Europe ($60.1 bn), tUe United States ($50.6 bn) and Japan

Table 3–16: Equivalent Variation (percentage of GDP)

	Industrial Products Trade Liberalisation	Services Trade Liberalisation	Industrial Products and Services Trade Liberalisation
United States	0.3	0.7	0.9
Canada	0.4	1.6	2.0
Mexico	0.1	2.7	2.8
Europe	0.3	0.6	0.9
Japan	0.6	0.8	1.4
Asian NICs	2.4	I.I	3.6
Australia-New Zealand	1.2	2.8	3.6
Other Trading Nations	0.0	1.0	1.0

($40.4 bn) Uave tUe largest EV figures for tUe combined reforms, but tUe Asian NICs and Australia-New Zealand Uave tUe UigUest welfare gains as percentages of GDP. Welfare gains from services liberalisation are more significant tUan from industrial product liberalisation in every region except Asian NICs.

3.3.3 Nguyen, Perroni and Wigle (1991, 1993, 1994, 1995)

The Nguyen *et al.* studies are unique in that tUey were performed at different stages of the Uruguay Round completion. These studies tUerefore give a good opportunity to compare and contrast tUe potential effects of reform (Nguyen *et al.* (1991)), tUe Draft Final Act (Nguyen *et al.* (1993)) and tUe final agreement (Nguyen *et al.* (1995)). EacU study uses an identical model (wUicU will Uere be labelled tUe NPW model).

The NPW model is a fairiy standard model. witU constant returns to scale tecUnology and perfect competition. TUree factors of land (labour, capital and land) provide

Table 3-17: Commodity and regional classification

Ten trading countries/blocs:	9 sectors/product groups
Middle income agricultural exporters (AGX)	Agriculture/food (AGR)
Middle income agricultural importers (AGM)	Basic/intermediate (BSD
Centrally planned economies (CNP)	Mining/extraction (MIN)
Other West European (OWE)	Light industries (LIN)
United States (USA)	Forestry/fishing (FRF)
Canada (CAN)	Finished capital goods (FCG)
European Community (EEC)	High-tech manufacturing (HTC)
Japan (JAP)	Intermediate manufacturing (INM)
Australia/New Zealand (ANZ)	Non-factor services (SVC)
Rest of World (ROW)	

income for one UouseUold in eacU region, in addition to net tax income. TUe Armington assumption is used to differentiate goods from different countries.

The commodity and regional classification of the model is sUown in Table 3-17. While some effort has been taken to disaggregate LDC regions into agricultural importers and exporters, it is clear tUat tUe regional classification is more useful for evaluating developed country effects of reform. TUe commodity classification is manufactures-based: agriculture and food are treated as a single commodity, and tUere is no textile and clotUing commodity.

One of tUe strengtU of tUe NPW model is tUat tUe autUors calibrate levels of service protection to reflect non-tariff barriers to trade in services, and use estimates of service liberalisation at eacU stage of tUe Uruguay Round. Few otUer studies include liberalisation of services trade.

Note tUat textiles are not included as a separate sector, but are part of "LigUt industries". MFA liberalisation is treated as tUe appropriate reduction in export taxes for tUis sector.

4 policy scenarios

- from 1991 paper *(ex ante),* 'Comprehensive outcome' = progress in agriculture, MFA abolition, services. NPW(1995) note tUat tUis scenario is fairly close to tUe Dunkel Draft.

- from 1991 paper *{ex ante),* 'Face-saving outcome' = modest cUanges in agriculture, MFA continues, no progress in services,

- from 1993 paper *{ex post),* 'Draft Final Act' = reducfion in support and border measures in agriculture, complete pUasing-out of MFA, tariffs and NTBs cut in manufactures, reducfion in NTBs in services (see paper for details).

- from 1995 paper *{ex post),* 'Final Agreement' = tariffication of NTBs and reduction in domestic support and export subsidies in agriculture; complete phasing-out of MFA; tariffs and NTBs cut in manufactures - 50% on basic/intermediates and higU-tecU except by ROW & CNP, ROW cut tariffs by

Table 3-19: Welfare outcomes (Hicksian **equivalent variation)** from the **NPW model**

Region	Comprehensive		Face-•saving		Draft Final Act		Final Agreement	
	(%)[1]	($bn)	(%)	($bn)	(%)	(Sbn)	(%)	(Sbn)
AGX	2.3	12.1	0.5	2.5	0.9	12.2	0.2	2.8
AGM	2.9	7.6	1.6	4.2	1.9	7.1	0.6	2.3
CNP	0.6	23.6	0.2	6.6	0.9	37.4	0.3	10.9
OWE	1.6	9.3	0.7	4.0	2.1	8.1	0.8	3.0
USA	1.7	73.7	0.8	35.3	0.8	36.4	0.2	9.6
CAN	2.5	9.3	1.2	4.4	0.9	3.7	0.3	1.2
EEC	1.7	60.4	0.8	27.5	1.8	61.3	0.5	19.0
JPN	2.5	50.1	1.4	27.6	2.0	27.0	1.3	17.8
ANZ	1.6	3.2	0.4	0.9	1.1	2.4	0.3	0,6
ROW	0.7	13.3	0.3	5.6	0.6	16.4	0.1	2.7
Worid	1.5	262.5	0.7	118.7	1.1	212.1	0.4	69.9

1: As percentage of GNP

30%, NTBs by 40%, and 30% cut in tariffs, 40% cut in NTBs on other goods (except by CNP); 20% reduction in NTBs in services.

Several conclusions can be drawn from a simple comparison of welfare results at various stages of the Uruguay Round. TUe final agreement obviously falls far sUort of the potential welfare gains available from compreUensive reform, but tUe DFA would have captured most of tUe welfare gains available. It is clear tUat tUe low welfare gains from the final agreement come from the watering-down of reforms *after* the DFA. It is interesting to note tUat NPW's "face-saving" scenario was at tUe time (1991)

Table 3-18: **Breakdown of** welfare **impacts** (Sbn) **from final** agreement

Region	Overall	Agriculture	Textiles and Clothing	Services	Tariffs
AGX	2.8	1.2	0.9	0.3	0.4
AGM	2.3	1.5	0.4	0.2	0.2
CNP	10.9	0.9	2.4	2.7	4,9
OWE	3.0	1.8	0.3	0.2	0.7
USA	9.6	4.1	3.0	0.5	2.0
CAN	1.2	0,6	0.2	0.1	0.3
EEC	19.0	12.7	1.8	1.5	3.0
JPN	17.8	14.5	-0.2	0.2	3.3
ANZ	0.6	0.4	0.1	0.1	0.0
ROW	2.7	-0.6	I.1	0.1	2.1
World	69.9	36.9	10.1	5.9	17.0

considered to be tUe absolute minimum level of liberalisation tUat would occur in tUe Uruguay Round, but welfare gains from tUe final agreement are 40% lower tUan tUe face-saving scenario.

Table 3–18 sbows tUe breakdown of welfare gains from tUe final agreement (1995 paper), and shows tUat tUe agricultural components of tUe Round have the largest overall effect. Agricultural importing LDCs (AGM) gain from agricultural liberalisation. BotU textiles and clotUing and tariff reforms Uave a more significant impact tUan service liberalisation, whicU may be due to tUe fact that the extent of service liberalisation (20% reductions in *ad valorem* equivalent tariffs) is low.

3.4 TARIFF REDUCTIONS

As a result of the Uruguay Round agreement, tariff rates (including converted non-tariff barriers) must on average be reduced by 36% over tUe implementation period, with LDCs being allowed a $^{1}/_{3}$ lower reduction (24%). TUese average tariff reductions apply to all goods, including agricultural and food goods. WitUin tUis simple formulaic agreement exist mucU more complicated aspects of tUe agreement. TUe *actual* tariff cUanges tUat will be implemented are tUose tUat GATT signatory countries submitted to GATT as part of tUe Uruguay Round Agreements. TUese tariff changes must comply witU tUe principles agreed upon, but countries Uave a large degree of leeway in making tariff cUanges wUere tUe averages must add up to 36% (24%) reductions. Because of tUis, using tariff reductions derived from GATT submissions is a more detailed modelling approacU tUan using across-tUe-board 36% (24%) reducfions.

Apart from needing to add up to certain averages, tUe Uruguay Round Agreement set a maximum tariff rate of 75%, wUicU put an additional constraint on countries as tUey drew up tUeir submissions to GATT. Minimum access provisions for agricultural goods tUat were previously subject to non-tariff barriers (imports must be at least 5% of sales in eacU good) provide a furtUer constraint, altUougU tUis constraint is only binding *after* tUe implementation; countries need not reduce tariffs in tUe submissions to guarantee minimum access, but must bear tUis constraint in mind because if tUe provision is not met, tariffs will Uave to be furtUer reduced at a latter date.

Agriculture and food present furtUer problems for tUe construction of tariff reduction data. Some countries gained exemptions for certain commodities (i.e. Japan for grains), but tUese exceptions present a minor difficulty wUen compared to tUe issues resulting from tUe fact tUat because agriculture Uad never before been subject to GATT disciplines, tUere were no existing tariff bindings for agricultural goods. TUis means tUat countries Uad to declare a pre-Uruguay Round binding (which must be equal or above existing tariffs) and a post-Uruguay Round binding, which must be on average 36% (24%) lower, with a minimum 15% (10%) cut on each tariff line. It would be possible for a country to declare pre-Uruguay Round bindings tUat were mucU larger tUan existing tariffs, and tUen reduce tUe bindings so tUat applied tariffs could rise substantially.

Harrison *et al.* (1995) use GATT data on pre-UR MFN tariff rates and tUe new tariff bindings submitted by countries as part of tUe Uruguay Round annex. Table 3-20 shows tUe percentage reduction in tariff rates, calculated from tables in Harrison *et al.* The fact tUat tUese use MFN rates ignores special and differential treatment for LDCs, and in some cases, ignores free trade areas.

Francois *et al.* (1995a) derive botU pre-Uruguay Round and post-Uruguay Round tariffs from GATT's Integrated Database. Table 3-21 gives tUe derived percentage reductions in tariff rates. Francois *et al.* (1994) use tUe same tariff data as tUe 1995a paper, but for a more aggregate classification of commodities and regions, and witU the exception of agricultural goods. TUe 1994 paper assumes 36% (24% for LDCs) reductions in tUe applied tariff rates for all agricultural products in every region. witU additional minimum market access provisions meaning tUat tariffs will fall even more if necessary. TUe 1995a paper assumes tUat no tariff reductions will be made for agricultural products in any region, except wUere minimum market access provisions require tariffs to fall.

Francois *et al.*(1995a) uses tUe GTAP version 2 database, and gives tariffs for tUe whole (37 good) commodity aggregafion. TUe regional aggregation is different, however, as sUown in Table 3-11. Francois *et al.* does not include service liberalisation - protection in tUe service sectors is zero (as in tUe GTAP database), and

Table 3-10: Derived Tariff Reductions from Harrison *et al.**

	AUS	NZL	CAN	USA	JPN	KOR	EU	IDN	MYS	PHL	SGP	THA	ARG	BRA	MEX	LAM	SSA	MNA	EIT	SAS	EFTA
PDR	[illegible]	91%	0%	0%	11%	0%	0%	0%	0%	[illegible]	[illegible]	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%
WHT	[illegible]	[illegible]	0%	[illegible]	[illegible]	95%	0%	0%	95%	95%	[illegible]	95%	0%	20%	0%	0%	21%	0%	0%	0%	0%
GRO	0%	0%	0%	0%	[illegible]	71%	0%	0%	71%	71%	63%	71%	[illegible]	0%	0%	0%	0%	0%	0%	0%	0%
NGC	0%	0%	0%	0%	[illegible]	8%	0%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9%	0%	0%	0%	0%	0%	0%	330%	[illegible]
FRS	44%	[illegible]	[illegible]	[illegible]	50%	49%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	46%	[illegible]	12%	0%	7%	0%	0%	21%	27%	67%
PCR	[illegible]	[illegible]	0%	0%	0%	47%	0%	0%	47%	47%	[illegible]	47%	0%	0%	0%	0%	0%	0%	0%	0%	0%
MIL	[illegible]	[illegible]	0%	0%	[illegible]	0%	0%	0%	0%	0%	90%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
TEX	43%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	26%	22%	32%	28%	[illegible]	54%	7%	46%	0%	7%	6%	0%	29%	10%	[illegible]
WAP	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13%	16%	[illegible]	[illegible]	0%	62%	8%	47%	0%	6%	0%	0%	17%	0%	33%
CRP	[illegible]	[illegible]	50%	[illegible]	[illegible]	60%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14%	18%	34%	0%	8%	[illegible]	0%	25%	37%	42%
I_S	[illegible]	25%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0%	0%	0%	0%	[illegible]	[illegible]	14%	0%	4%	0%	0%	8%	49%	[illegible]
NFM	60%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	19%	2%	14%	[illegible]	0%	34%	7%	17%	0%	8%	[illegible]	0%	16%	7%	35%
FMP	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	37%	46%	1%	[illegible]	[illegible]	0%	[illegible]	9%	27%	0%	13%	0%	0%	21%	4%	40%
TRN	16%	6%	[illegible]	4%	[illegible]	18%	14%	1%	1%	0%	0%	[illegible]	9%	[illegible]	0%	10%	0%	0%	[illegible]	35%	14%
MEA	91%	87%	0%	[illegible]	[illegible]	41%	9%	6%	87%	2%	[illegible]	[illegible]	0%	20%	0%	0%	[illegible]	0%	0%	0%	0%
ENR	50%	[illegible]	0%	0%	[illegible]	20%	[illegible]	0%	5%	[illegible]	0%	0%	0%	0%	0%	6%	0%	0%	7%	5%	1%
MAN	[illegible]	[illegible]	53%	[illegible]	[illegible]	27%	[illegible]	6%	[illegible]	[illegible]	0%	[illegible]	5%	13%	0%	9%	0%	0%	25%	31%	[illegible]
FOO	0%	0%	0%	0%	0%	29%	0%	0%	[illegible]	[illegible]	[illegible]	29%	[illegible]	0%	0%	22%	0%	0%	0%	0%	0%
MAC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	52%	[illegible]	[illegible]	46%	[illegible]	0%	26%	24%	30%	0%	11%	0%	0%	17%	29%	[illegible]

N.B. No tariff reductions for China, Hong Kong, and Taiwan (not GATT/WTO members)

*: For codes, see Table 3-3 (commodities) and Table 3-5 (regions).

all agricultural and food tariffs are reduced by 36% (24% in LDCs) except in CUina, whicU is excluded from all reforms.

The derived tariff cUanges from Francois *et al.* (Table 3-21) sUow great variability across product groups and regions. Some sectors, sucU as coal (col) and transport goods (trn) are subject to small tariff reductions, while otUer sectors sucU as pulp paper products (ppp) and ferrous metals (i_s) Uave very large reductions.

Because the Harrison *et al.* (1995) and Francois *et al.* (1995) papers use different regional and commodity classificafions, a full comparison of the tariff reducfions is impossible. It is possible, however, to compare tUe tariff reductions in tUe few cases tUat regional and commodity classificafions matcU. Table 3-22 sbows tUis comparison, for tUe six regions and seven sectors tUat are identically defined in botU models.

Table 3-21: Derived tariff reductions from Francois *et al.* (1995a)*

	ANZ	JPN	CAN	US	EU	EFTA	LA	SA	EA	SSA	EIT	ROW
FRS	0%	0%	0%	100%	0%	50%	43%	1%	13%	0%	10%	22%
FSH	29%	28%	34%	25%	17%	18%	35%	0%	77%	0%	4%	6%
COL	0%	0%	0%	0%	100%	100%	0%	0%	3%	0%	8%	0%
OIL	0%	0%	0%	0%	0%	17%	19%	0%	0%	0%	0%	76%
GAS	60%	100%	0%	0%	0%	44%	0%	0%	0%	0%	0%	0%
OMN	30%	47%	50%	46%	22%	18%	23%	36%	41%	0%	17%	17%
TEX	41%	19%	37%	29%	24%	34%	29%	11%	33%	0%	29%	50%
WAP	31%	22%	28%	9%	13%	33%	21%	0%	20%	0%	17%	31%
LUM	51%	33%	41%	41%	48%	43%	34%	8%	22%	0%	22%	22%
PPP	51%	100%	100%	100%	100%	76%	17%	52%	39%	0%	23%	23%
P_C	44%	89%	32%	29%	38%	29%	23%	28%	34%	0%	29%	9%
CRP	37%	61%	49%	40%	45%	48%	32%	38%	28%	0%	27%	32%
IJ	84%	85%	95%	96%	91%	85%	7%	47%	47%	0%	9%	2%
NFM	43%	41%	45%	7%	18%	28%	21%	4%	26%	1%	21%	38%
FMP	23%	74%	38%	40%	46%	42%	29%	16%	19%	0%	19%	6%
TRN	25%	100%	33%	4%	9%	17%	29%	31%	15%	0%	6%	28%
OME	32%	89%	52%	56%	51%	43%	26%	32%	25%	0%	17%	17%
LEA	10%	10%	37%	13%	30%	27%	25%	1%	38%	0%	24%	2%
NMM	30%	37%	62%	33%	28%	33%	16%	18%	17%	0%	23%	58%
OMF	33%	62%	54%	68%	47%	52%	30%	27%	33%	0%	20%	20%

*: For region codes, see Table 3-11. Francois *et al.* give tariff reducfions for eacU non-agricultural sector in tUe GTAP database; see CUapter 4, Table 4-1 for tUese commodity codes.

Both Harrison *et al.* and Francois *et al.* calculate their tariff reductions in the same way, using the GATT Integrated Database (IDB). and comparing pre-UR applied tariffs witU post-UR tariff bindings, and assuming tUat tUe appropriate tariff reduction will take place wUere the new binding is below tUe pre-UR applied tariff and that wUere tUe new binding is above the pre-UR applied tariff, tUere will be no change in the applied tariff TUis is conducted at a disaggregate level and tUen aggregated to tUe level of tUe database.[4] Table 3-22 sUows tUat while there are many sectors where the tariff reductions are very close. there are a few discrepancies: Non-ferrous metals (NFM) in tUe USA (25%,7%) and Japan (63%,41%) are perhaps the largest.

Table 3-23 shows tUe pre-UR and post-UR tariff rates, and the percentage reduction tUat are reported in Hertel *et al.* Unlike Harrison *et al.* and Francois *et al.,* tUis paper does not report tariffs at the level tUat tUey are used, but presents tUis summary table. Table 3-24 sUows a similar table from Brown *et al.* (1995).

Examination of tUese tables sUow tUat tUere is some degree of uncertainty over wUat level of tariff reducfions will take place as a result of tUe Uruguay Round agreement. TUé point wUere authors have tUe most dissimilar tariff reduction data.is EU agriculture, wUere Francois *et al.* (1994) use 36% reductions for all goods, Francois *et al.* (1995a) use no reducfions but enforce minimum market access provisions, Harrison *et al.* use 0% reductions except for meat (9%), Hertel *et al.* report an average 2% reduction, and Brown *et al.* report an average

Table 3-22: Comparison of Tariff Reductions

	JPN		CAN		USA		EU		EFTA		SSA	
	HRT	FMN	HRT	FMN	HRT	FMN	HRT	FMN	HRT	FMN	HRT	FMN
TEX	32%	19%	36%	37%	29%	29%	26%	24%	34%	34%	6%	0%
WAP	33%	22%	27%	28%	10%	9%	13%	13%	33%	33%	0%	0%
CRP	55%	61%	50%	49%	42%	40%	38%	45%	42%	48%	1%	0%
I_S	89%	85%	89%	95%	92%	96%	86%	91%	85%	85%	0%	0%
NFM	63%	41%	38%	45%	25%	7%	19%	18%	35%	28%	10%	1%
FMP	82%	74%	39%	38%	39%	40%	46%	46%	40%	42%	0%	0%
TRN	100%	100%	36%	33%	4%	4%	14%	9%	14%	17%	0%	0%

HRT: Tariff reductions calculated from Harrison, Rutherford and Tarr (1995)
FMN: Tariff reductions calculated from Francois, McDonald and Nordstrom (1995a)

[4] In tact, Harrison *et al.* use a World Bank database that contains the IDB data aggregated to the GTAP classifications, while Francois *el al.* use the IDB data. There should, however be no difference in tariff rates calculated these ways.

11% reduction.

Without any *a priori* reason to prefer one set of tariff reduction estimates over any otUer set of estimates, tUe data in Table 3-25 will be used in chapter 6 to simulate tUe Uruguay Round.

Table 3-23: Average Pre-UR, Post-UR tariffs and import price changes from Hertel *et al.* (1995)

	Food			Manufactures		
	Pre-UR %	Post-UR %	Reduction %	Pre-UR %	Post-UR %	Reduction %
US and Canada	11.7	11.0	6%	4.3	2.8	35%
European Union	26.5	26.0	2%	6.5	3.9	40%
Japan	87.8	56.1	36%	4.9	2.1	57%
Korea	99.5	41.1	59%	16.1	8.2	49%
Hong Kong	0	0	0	0	0	0
Indonesia	21.9	15.5	29%	14.2	13.5	5%
Malaysia	87.9	34.3	61%	11.0	7.7	30%
Philippines	86.9	33.4	62%	23.9	21.5	10%
Thailand	59.8	34.5	42%	36.2	27,6	24%
Latin America	2.3	1.5	35%	17.1	14.9	13%
Sub-Saharan Africa	15.6	12.4	21%	9.5	9.4	1%
South Asia	-3.5	-4.3	-23%	51.9	37.1	29%
Rest of World	15.7	14.1	10%	10.6	9.1	15%

Table 3-24: Average Pre-UR, Post-UR tariffs and import price changes from Brown *et al.* (1995)

	Agricultural Products			Industrial Products			Services
	Pre-UR %	Post-UR %	Change %	Pre-UR %	Post-UR %	Change %	Post-UR %
United States	14.9	14.0	6.0	4.9	3.4	30.3	67.5
Canada	2.6	2.3	14.9	7.7	4.5	42.2	57.2
Mexico	35.3	35.3	0.0	11.9	11.9	0.1	76.9
Europe	13.2	11.7	11.1	6.9	4.8	30.4	79.2
Japan	60.9	35.1	42.4	6.0	3.9	36.2	61.2
Asian NICs	12.7	7.9	37.3	0.9	0.7	17.2	46.0
Australia and New Zealand	0.8	0.4	44.8	13.8	9.1	34.3	105.9
Other Trading Nations	18.6	17.6	5.3	28.9	21.0	27.2	107.4

Table 3-25: Tariff reductions from Harrison(1995)

	USA	EU	Japan	Other OECD	LDCs	China
Agriculture	36%	36%	36%	36%	24%	0%
Forestry	21%	17%	29%	34%	56%	0%
Mining	36%	27%	56%	49%	18%	0%
Textiles	29%	25%	20%	37%	33%	.0%
Wearing Apparel	9%	13%	22%	28%	26%	0%
Primary Iron and Steel	95%	91%	85%	95%	31%	0%
Non ferrous metals	7%	18%	42%	44%	21%	0%
Fabricated metal products	41%	46%	74%	38%	19%	0%
Chemicals, rubber and plastics	40%	45%	61%	48%	31%	0%
Transport machinery	5%	13%	100%	34%	37%	0%
Other machinery	57%	55%	52%	34%	26%	0%
Other manufacturing	30%	40%	38%	40%	27%	0%

3.5 COMPARISON OF STUDIES

Table 3-26 and Table 3-27 sUow some comparisons between tUe model structures and results of CGE models of tUe final Uruguay Round agreement. Studies tUat simulate hypothetical trade liberalisation, or tUat simulate tUe reforms proposed at a certain stage of the Round are excluded from tUis table.

Table 3-26 gives some (limited) information on tUe models: tUe model and database, base year and evaluation year, and sector and region classification levels. Most of tUese papers are GTAP-based, using various versions of tUe database. Five of tUe models use projections - for these models tUe base year and evaluation year are different, wUereas tUey are tUe same for static models.

Noticeably, few models disaggregate tUe agricultural sectors to a great extent, except for tUe RUNS model. Harrison *et al* (HRT) Uas tUe next UigUest level of agricultural detail. witU four agricultural and four food processing sectors. TUis paper uses more sectors tUan any otUer GTAP-based model, so tUat it Uas more agricultural sectors does not particularly reflect a special agricultural focus.

Many of the papers Uave a particular focus that is not shown in tUese tables; HMYD, HBDM and YMY are particular models of tUe MFA, while HME examines the effects of the Uruguay Round on Africa.

Table 3-27 shows a comparison of the main results of tUese papers. TUe first four columns report global EV as a percentage of GDP for different market structures, where those market structures are modelled. The middle four columns give tUe proportion of global EV gains tUat originate from eacU of tUe four main categories of reform. Blanks in all of tUese columns indicates that the autUors did not report results for simulations of tUe components of tUe Uruguay Round, and a dasU (-) indicates tUat tUat component is not included in the paper's characterisation of the Uruguay Round. BDRS, for example, model industrial and service reforms, but do not model agricultural or MFA reforms. TUe final four columns report tUe percentage welfare gain to tUree regions - tUe EU, Japan and tUe USA (in some cases tUe USA column is taken from results for USA & Canada or NAFTA regions) and for LDCs as a whole. The LDC column is rarely given in papers; in most cases it is estimated Uere.

A simple arithmetic average is given in the final row for the first four and last four columns. The average global EV for constant returns to scale (CRTS) models with perfect competition (PC) is a good indication of the global welfare gains that CGE models predict for the Uruguay Round, and is an average of ten estimates, wUicU range from 0.17 to 0.89. TUe averages show that the inclusion of increasing returns to scale (IRTS) and monopolistic competition (MC) leads to UigUer welfare implications. TUis is particularly evident from FMN94 and FMN95a, wUicU use a version of monopolistic competition witU Uigh elasticities and varietal scaling effects. while HRT, using lower elasticities and witUout varietal scaling, find that IRTS/MC makes only sligUt differences to tUeir results. HRT find tUat steady state dynamics are more important, while FMN95a find tUat tUis affects tUeir results very little. Note that the average for tUe steady state column in Table 3-27 vary widely over tUe spectrum of commodity and regional aggregation, and in tUeir cUaracterisation of tUe Uruguay Round FMN94 Uas a very optimistic interpretation of tUe agricultural agreement, while FMN95a adopts a '*de minimis*' scenario. BRR uses a similar representation of tUe Round as FMN94, and tUe percentage contributions of components from tUese papers are very similar, altUougU tUe overall welfare resuUs vary because of otUer modelling differences.

The regional gains from tUe Uruguay Round sUow tUat tUe welfare gains from tUe Round for both the EU and USA will be approximately tUe same percentage of GDP as tUe global gains, with the EU gains sligUtly UigUer tUan tUe USA gains (note tUat in no paper do tUe USA gains exceed tUe EU gains). TUe gains to Japan are significantly UigUer tUan tUe world average.

3.6 CONCLUSIONS

This chapter Uas reviewed tUe main global CGE models and tUe most important papers based on these models tUat look at tUe Uruguay Round reforms. TUe GTAP model is tUe most widely used of tUese models, as is indicated by tUe predominance of GTAP-based applications in Table 3-26. Alternatives to GTAP do exist, tUougU, witU different strengtUs and weaknesses: RUNS Uas tUe best treatment for agriculture in LDCs, tUe MicUigan model has the best treatment of industrial goods in developed countries, and witU Nguyen *et al.* have the advantage of including barriers to trade in tUe service sectors. TUe strengtUs of GTAP over all of tUese is tUe database size and tUe detail of bilateral trade flows tUat it includes.

It is therefore impossible to cUoose one model as being 'best' for a study of tUe Uruguay Round without first making a judgement on wUicU set of countries and sectors are tUe most important in tUe Round. In many cases tUe cUoice of data, model and aggregation will predetermine tUe relative importance of different parts of tUe Round, and tUe relative welfare effects, explaining many of tUe different results in tUe papers reviewed Uere. OtUer issues of how to implement tUe Uruguay Round reforms in a CGE model and of market structure will also have effects on resuUs.

The next chapter will examine tUe GTAP database, used Uere in preference to otUers in part because of its public availability but also because of its larger size and bilateral trade detail, and will determine an aggregation to be used in CUapter 6. drawing on tUe points developed here.

Table 3-26: Uruguay Round Simulations

Code	Paper	Database	Year Base/ Evaluation	Sectors Total	Agricultural	Food	Textiles	Primary	Manufactur	Services	Regions Total	DMEs	EITs	NICs	Other LDCs
HRT	Harrison, Rutherford and Tarr 1995	GTAP 2	1992/1992	21	4	4	2	2	7	2	24	7	1	4	12
FMN 94	Francois, McDonald and Nordstrom 1994	GTAP 1	1990/1990	15	2	0	2	3	8	2	9	6	0	0	3
FMN 95a	Francois, McDonald and Nordstrom 1995a	GTAP 2	1992/1992	19	3	1	2	3	9	1	13	6	1	0	6
BRR	Blake, Rayner and Reed 1996	GTAP 2	1992/1995	16	2	1	1	1	4	1	10	4	0	1	5
YANG	Yang 1994	GTAP 2	1995/1995	16	1	0	0	0	8	1	10	*	*	*	*
HMYD	Hertel, Martin, Yanagishima and Dimaranan 1995	GTAP 2	1992/2005	10	1	1	2	1	3	2	15	3	0	3	8
HBDM	Hertel, Bach, Dimaranan and Martin 1996	GTAP 3	1992/2005	10	1	1	2	1	3	1	15	3	0	3	8
YMY	Yang, Martin and Yanagishima	GTAP 3	1992/1992	10	1	1	2	1	4	1	10	4	0	1	5
HME	Hertel, Masters and Elbehri 1998	GTAP 3	1992/2005	12	3	1	1	3	1	2	10	2	1	1	6
RUNS	Goldin and van der Mensbrugghe 1995	RUNS	1985/2002	20	15	0	0	0	4	1	22	6	2	1	13
NPW	Nguyen, Perroni and Wigle 1995	own model	1993/1993	9	1		0	2	5	1	10	8	1	0	3
BDS	Brown, Deardorff, Fox and Stern 1995	Michigan	1990/1990	29	1	1	2	1	18	6	9	5	0	1	3
HT	Haaland and Tollefsen 1994	own model	1985/1992	15	0	0	0	0	12	1	4	4	0	0	0

notes: * Yang 1994 is an unpublished manuscript. The details here are from Francois *et al.* 1996, who do not give details on the regional aggregation.

Table 3-27: Global gains from the Uruguay Round

	Equivalent Variation as a percentage of GDP: various model structures				Percentage contribution of each Uruguay Round component (CRTS/PC model)				Regional gains from CRTS/PC model or main model (percentage of GDP)			
	CRTS/PC	IRTS/PC	IRTS/MC	CRTS/PC Steady State	Agriculture	MFA	Industrial Tariffs	Services	EU	USA	Japan	LDCs
[illegible]	[illegible]		[illegible]	0,71	[illegible]	15	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] 94	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	-	[illegible]	0.54	[illegible]	[illegible]
[illegible] 95	[illegible]		[illegible]	0,45	[illegible]	47	[illegible]	-	0.22	0.17	[illegible]	*0.4*
[illegible]	[illegible]	-	[illegible]	-	[illegible]	[illegible]	40	-	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]*	[illegible]	[illegible]	-	-	[illegible]	29	24	-	*	*	*	*
[illegible]	[illegible]	-	-	-	[illegible]	[illegible]	14	-	0.72	[illegible]	[illegible]	*1.40*
[illegible]	[illegible]	-	[illegible]	-	[illegible]	29	24	-	[illegible]	[illegible]	[illegible]	-
[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	-	-	-					[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	•	-	-	*0.3*					[illegible]	[illegible]	[illegible]	*0.0*
[illegible]	[illegible]	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	-	*1.3*	-	-	-	*53*	*[illegible]*	[illegible]	[illegible]	1.4	[illegible]
[illegible]	-	-	[illegible]	0,21					[illegible]	0.0,05	[illegible]	-
Average	[illegible]	[illegible]	[illegible]	0,4					[illegible]	[illegible]	[illegible]	[illegible]

notes: Italicised figures are approximate estimates, as the authors do not give the appropriate results.

A dash (-) in the first four columns indicates that the model structure is not used in that particular paper; in the middle four columns it indicates that the component is not included in the paper as part of the Uruguay Round; and in the final four columns, that the region is not defined in the paper.

*Yang 1994 is an unpublished manuscript. The details here are from Francois *et al.* 1996, who do not give details on the regional aggregation.

CHAPTER 4

THE GLOBAL TRADE ANALYSIS PROJECT DATABASE

Chapter 4 discusses tUe GTAP database in detail. Section 4.1 covers tUe regional and sectoral coverage of tUe database and section 4.2 examines tUe accounting relationsUips tUat tUe database uses. Section 4.3 outlines tUe limitations of tUe database while section 4.4 details tUe particular advantages tUat tUe database brings to users. Section 4.5 examines tUe values of key data, firstly for regional aggregate data, and then for detailed data for each region. Section 4.6 discusses the aggregation of tUis database, and section 4.7 is of a metUodological nature, detailing Uow tUe database is transformed for use witU tUe model presented in CUapter 5.

4.1 THE GTAP DATABASE

4.1.1 The GTAP Regions and Commodities

Table 4-1 sUows tUe 24 regions and 37 commodities detailed in version 2 of tUe GTAP database. Of tUe 37 commodities, six are agricultural (pdr to olp). Paddy Rice, Wheat and OtUer Grains are all cereals products, but it is useful to have tUem defined separately - particularly as tUe global patterns of production, trade, consumption and protection of tUese products are very different. TUe presence of Wool as a separate product is probably due to GTAP's origins in tUe Australian SALTER database, as many otUer sectors tUat are larger globally are not defined, yet Wool is very important to Australia. All otUer agricultural products are grouped into two sectors - Non-Grain Crops and OtUer Livestock Products, wUicU are botU very diverse groups of goods. Non-Grain Crops includes sugar, oil seeds, vegetables, fruU, plant-based fibres and cash-crops sucU as coffee, tea and cocoa. OtUer Livestock Products includes milk, all meat, and otUer animal products (sucU as skins). For all tUese agricultural goods, tUe commodities are tUe 'raw' unprocessed forms, wUicU are tUen purcUased as intermediate inputs by tUe Food processing industries. These agricultural sectors are the only sectors to use land as a primary factor input.

Six other primary products are defined (frs to omn), covering Forestry (which is used extensively as an intermediate input to Lumber and Pulp Paper Products), Fisheries (used in Other Food Products), three fuel extraction sectors, Coal, Oil and Gas (used mainly in Petroleum and Coal and Chemicals Rubbers and Plastics), and Other Minerals - which covers the mining and quarrying of all non-fuel minerals.

Five food product commodities (pcr to b_t) are defined as Paddy Rice, Meat Products, Milk Products, Other Food Products and Beverages and Tobacco. While these sectors are not 'agriculture' (and do not use land) tUey purcUase agricultural goods as intermediates, and a considerable degree of agricultural protection operates through these industries.

Fourteen manufacturing goods (tex to omf) are defined, and tUese are best considered as three sub-groupings; textiles and clothing, resource products and final manufactures. Textile and clothing consists of two sectors: Textiles and Wearing Apparel. These two sectors are unique because of the MFA protection that is present on exports from developing countries to developed countries. Textiles purchases inputs from Non-Grain Crops in particular, while Wearing Apparel purchases its intermediates mainly from Textiles.

Eight resource products can be identified, each being dependant on the use of certain primary products. Leather Products uses mainly Other Livestock inputs. Lumber and Pulp Paper Products use Forestry, Petroleum and Coal and CUemicals, Rubbers and Plastics use Coal, Oil and Gas inputs. Non-Metallic Minerals. Primary Ferrous Metals and Non-Ferrous Metals use inputs from tUe OtUer Minerals sector.

The bulk of manufacturing activities in developed economies falls into four final manufacturing sectors: Fabricated Metal Products, Transport Industries, OtUer Machinery and Equipment, and Other Manufactures. Each of these sells goods to final consumers, while Transport Industries (cars, sUips, planes) also sells products to Trade and Transport services and all otUer sectors as plant (sucU as tractors). OtUer

Table 4–1: Commodity and country coverage of the full GTAP database[1]

COMMODITIES		COUNTRIES AND REGIONS	
pdr	Paddy Rice	AUS	Australia
wht	Wheat	NZL	New Zealand
gro	Other Grains	CAN	Canada
ngc	Non-Grain Crops	USA	United States of America
wol	Wool	JPN	Japan
olp	Other Livestock Products	KOR	Republic of Korea
frs	Forestry	E_U	European Union (EU-12)
fsh	Fisheries	IDN	Indonesia
col	Coal	MYS	Malaysia
oil	Oil	PHL	Philippines
gas	Gas	SGP	Singapore
omn	Other Minerals	THA	Thailand
pcr	Processed Rice	CHN	China
met	Meat Products	HKG	Hong Kong
mil	Milk and Milk Products	TWN	Taiwan
ofp	Other Food Products	ARG	Argentina
b_t	Beverages and Tobacco	BRA	Brazil
tex	Textiles	MEX	Mexico
wap	Wearing Apparel	LAM	Rest of Latin America
lea	Leather Products	SSA	Sub-Saharan Africa
lum	Lumber	MNA	Middle East and North Africa
ppp	Pulp Paper Products etc.	EIT	Economies In Transition
p_c	Petroleum and Coal	SAS	South Asia
crp	Chemicals Rubbers and Plastics	ROW	Rest of World
nmm	Non-Metallic Minerals		
i_s	Primary Ferrous Metals		
nfm	Non-Ferrous Metals		
fmp	Fabricated Metal Products		
trn	Transport Industries		
omc	Other Machinery and Equipment		
omf	Other Manufacturing		
egw	Electricity. Water and Gas		
cns	Construction		
t_t	Trade and Transport		
osp	Other Services (Private)		
osg	Other Services (Government)		
dwe	Ownership of Dwellings		

[1]: version 2. All data is for 1992.

Machinery and Equipment sells products mainly as intermediates and capital goods, but much machinery is also sold to final consumers.

The six service sectors (egw to dwe) are unique in that the GTAP database provides no data on protection for these products, but trade volumes are included (except for Construction and Ownership of Dwellings, which are defined to be non-traded).

Of the 24 regions. six are 'developed" - Australia, New Zealand, Canada. the United States. Japan and the European Union. The EU is always considered to be a single country (as opposed to a composite region) in the database because. with the minor exception that some member states give preferences to former colonies, trade protection and trade policy is uniform across the union. All EU data are calculated for the individual members and aggregated, except for input-output tables. where data for smaller member states are not included.

Of the remaining 18 regions, four are East-Asian Newly Industrialised Countries (Korea. Singapore, Hong Kong and Taiwan) and six are middle-income developing countries (Malaysia, the PUilippines, TUailand, Argentina, Brazil and Mexico). CUina and Indonesia are tUe only low income developing countries identified individually in the database.

The other six regions are composite regions. Other Latin America includes those Caribbean and SoutU American countries not included separately. Sub-SaUaran Africa excludes SoutU Africa. Middle East and NortU Africa excludes Israel. Economies in Transition includes tUe former Soviet Union countries and Eastern Europe (note tUat East Germany is included in tUe EU as part of Germany). SoutU Asia is India, Pakistan, BangladesU and Sri Lanka. TUe Rest of tUe World is tUe most diverse region - comprising Western European countries not in tUe EU12. SoutU Africa, Turkey, Israel. and smaller countries from around tUe world.

4.2 ACCOUNTING RELATIONSHIPS IN THE GTAP DATABASE

Accounting relationsUips are necessary in any model to provide a basis for tUe data and as a starting point for describing tUe equations of tUe model. Two areas tUat must first be addressed are tUe sets used in tUe model, and tUe definition of parameter names.

Sets used in the GTAP model

The following sets are used in tUe GTAP model. Included is an example of wUat eacU set would comprise if a particular tUree-region, three-commodity aggregation were chosen.

Table 4-2: **GTAP** Sets

r or s	Regions in the aggregation.	{USA, EU, ROW!
j	Traded commodities	{Food, Manufactures, Services}
f	Endowment commodities	{Land, Labour, Capital}
j	Produced commodities	[Food, Manufactures, Services, cgds',
k	Non-savings commodities	I Land, Labour, Capital, Food, Manufactures, Services, cgds}

where "cgds" refers to newly produced capital goods.

Definition of parameter names

Most GTAP parameters have a two- or three- character name, and some attention has been paid to making these parameter names consistent. The following conventions are used for most parameter names:

Table 4-3: Key to Parameter Names

Letter	**Means that the variable is...**
Values	
E	The value of an endowment supply or demand
V	A value (in 1992 US$ millions)
X	An export value
Volumes	
D	A domestic supply or demand (when not the last identifier)
I	An imported supply or demand
O	An output
F	A demand by firms
P	A private demand
G	A government demand
T	A demand for transport services
Evaluation Prices	
A	Evaluated at agent's prices
M	Evaluated at market prices
W	Evaluated at world prices
Evaluation Region	
S	By region of source
D	By region of destination (when appearing as the last identifier)
Parameters	
PAR	A private demand CDE parameter
ESUB	An elasticity of substitution

Using this convention. tUe Value of Output at Agents prices of any non-savings commodity in any region is VOA(k,r). VXWD(i,r,s) is tUe Value of eXports, at World prices and by Destination, of good i exported from source region r to destination region s.

4.2.2 GTAP database terms

Value Flows at Domestic Market Prices

VFM (f,j,r)	Value of Factor demand at Market prices, by factor, sector and region
VDFM(i,j,r)	Value of Domestic purcUases by Firms at Market prices, by commodity, sector and region.
VlFM(i,j,r)	Value of Import purcUases by Firms at Market prices, by commodity, sector and region.
VDPM(i.r)	Value of Domestic purcUases by Private households at Market prices, by commodity and region.
VlPM(i.r)	Value of Import purcUases by Private Uouseholds at Market prices, by commodity and region.
VDGM(i,r)	Value of Domestic purchases by Governments at Market prices, by commodity and region.
VlGM(i,r)	Value of Import purchases by Governments at Market prices, by commodity and region.
VXMD(i.r.s)	Value of eXports at Market prices of exporting region, by commodity, source region r and destination region s.
VIMS(i,r,s)	Value of Imports at Market prices of importing region, by commodity, source region r and destination region s.
VST(i.r)	Value of Sales to international Transport, by commodity and region.

Value Flows Evaluated at World Market Prices

VXWD(i.r,s)	Value of eXports at World (fob) prices, by commodity, source region r and destination region s.
VlWS(i.r.s)	Value of Imports at World (c.i.f.) prices, by commodity, source region r and destination region s.

Value Flows Evaluated at Agents' Prices

EVOA(f.r)	Endowment commodity Value of Output at Agents' prices, by factor and region.
EVFA(f,j,r)	Endowment commodity Value of purcUases by Firms at Agents" prices, by factor, sector and region.
VDFA(i,j,r)	Value of Domestic purcUases by Firms at Agents" prices, by commodity, sector and region.
VIFA(i,j,r)	Value of Imported purcUases by Firms at Agents" prices, by commodity, sector and region.

VDPA(i,r) Value of Domestic purcUases by Private households at Agents' prices, by commodity and region.

VIPA(i.r) Value of Imported purchases by Private households at Agents' prices, by commodity and region.

VDGA(i,r) Value of Domestic purchases by Governments at Agents" prices, by commodity and region.

VIGA(i,r) Value of Imported purchases by Governments at Agents" prices, by commodity and region.

SAVE(r) Value of net savings, by region.

VDEP(r) Value of capital depreciation, by region.

VKB(r) Value of beginning-of-period capital stock, by region.

Elasticities

Several elasticities are defined in the GTAP database. The elasticities use here are:

SIGV(i) Elasticity of substitution between factors of production in the value-added nest.

SlGD(i) Elasticity of substitution between domestic and import goods.

SIGiVl(i) Elasticity of substitution between imports from different source regions.

4.2.3 Derived Parameters

Many parameters that are used in GTAP modelling are not included in the database, but are easily calculated from database parameters.

Aggregate ***Parameters***

Some OtUer parameters are convenient for expressing sums of values.

VDM(i,r) Value of Domestic sales at Market prices, by commodity and region.

= VDPM(i.r) + VDGM(i,r) + I ,VDFM(i,j,r)

VIM(i,r) Value of Imports at Market prices, by commodity and region.

= Σ , VIMS(i.s,r)

VPM(i,r) Value of Private Demand for goods at market prices, by commodity and region.

= VDPM(i,r) + VIPM(i,r)

VGM(i,r) Value of Government Demand for goods at market prices, by commodity and region.

= VDGM(i,r) + VIGM(i,r)

VFIM(i,j,r) Value of Firms' Demand for goods at market prices, by commodity, sector and region. Note tUat VFM (tUe logical cUoice of name) is already defined as a parameter.

	= VDGM(i,j.r) + VlGM(i.j,r)
VPA(i,r)	Value of Private demand at Agents" prices, by commodity and region.
	= VDPA(i.r) + VlPA(i,r)
VGA(i,r)	Value of Government demand at Agents" prices, by commodity and region.
	= VDGA(i.r) + VIGA(i,r)
VFA(i,j,r)	Value of Firms" demand at Agents" prices, by commodity, sector and region.
	= VDFA(i,j,r) + VIFA(i.j,r)
VTWR(i,r,s)	Value of Transport services used in tUe transport of goods from source region r to destination region s.
	= VIWS(i,r,s) - VXWD(i,r,s)
VVA(j,r)	Value of Value-Added use, by commodity and region
	VVA(i,r) = I,VFM(f,i,r)
	VVA("cgds".r) = 0
VOA(j.r)	Value of Output at Agents" prices, by commodity and region.
	= VVA(j.r) + $\sum_i$ VFA(i,j,r)
VOM(j.r)	Value of Output at Market prices, by commodity and region.
	VOM(i.r) = VDM(i.r) + VST(i,r) + $\sum_s$ VXMD(i,r,s)
	VOM("cgds".r) = VOA("cgds".r)
INCOME(r)	Regional Income. by region (calculated in section 4.2.7).
EXPENDITURE(r)	Regional Expenditure, by region (calculated in secfion 4.2.6)
GLOBTRAN	Value of Transport services (globally).
	= $\Sigma_i \Sigma_r$ VST(i.r)
GLOBINV	Value of Global investment.
	= I, SAVE(r)
REGINV(r)	Regional investment, by region.
	= VOM("cgds".r)

Tax Revenues

Taxes are not included explicitly in tUe database (tUey may be calculated from tax-inclusive and tax-exclusive values). The following tax revenues are therefore implicit, and are negative where there are subsidies.

OTAX(i,r)	Output tax on the production of good i in region r.
	= VOM(i,r) - VOA(i.r)
XTAX(i,r,s)	Export tax by commodity, exporting region r and importing region s.

= VXWD(i,r,s) - VXMD(i,r,s)

MTAX(i,r,s) Import tax by commodity, exporting region r and importing region s.

= VIMS(i,r,s)-VIWS(i,r,s)

ETAX(f,j,r) Endowment (factor) tax by factor, sector of use and region. TUis parameter Uas been included by GTAP for compatibility with future versions even though all values are zero in version 2.

= 0

DPTAX(i,r) Tax on private consumption of domestically produced goods, by commodity and region.

= VDPA(i,r) - VDPM(i,r)

IPTAX(i,r) Tax on private consumption of imported goods, by commodity and region.

= VIPA(i,r)-VIPM(i,r)

DGTAX(i,r) Tax on government consumption of domestically produced goods, by commodity and region.

= VDGA(i,r) - VDGA(i,r)

IGTAX(i,r) Tax on government consumption of imported goods, by commodity and region.

= VIGA(i,r)-VIGM(i,r)

DFTAX(i,j,r) Tax on firms" use of domestically produced goods, by commodity, sector and region.

= VDFA(i,j,r) - VDFM(i,j,r)

IFTAX(i,j,r) Tax on firms" use of imported goods, by commodity, sector and region.

= VIFA(i,j,r)-VIFM(i,j,r)

Later, it will be convenient to define consumption/use taxes for aggregate (import + domestic) consumption and use. The value of revenues for these parameters are:

PTAX(i,r) Tax on private consumpfion of all goods, by commodity and region.

= DPTAX(i,r) + IPTAX(i,r)

GTAX(i,r) Tax on government consumption of all goods, by commodity and region.

= DGTAX(i,r) + IGTAX(i,r)

FTAX(i,j,r) Tax on firms' use of all goods, by commodity, sector and region.

= DFTAX(i,j,r) + IFTAX(i,j,r)

*Tax **Rates***

The following tax rates are defined. Any of these tax rates can be negative to give a subsidy, although the version 2 database only has subsidies for output (TO), exports (TX) and imports (TM).

TO(j.r)	Output tax by commodity and region = OTAX(j,r) / VOM(j,r)
TM(i,r,s)	Import tariff by cominodity and source-destination regional pairing = MTAX(i,r,s) / VIWS(i,r,s)
TX(i.r.s)	Export tariff by commodity and source-destination regional pairing = XTAX(i,r,s) / VXMD(i,r.s)
TFD(i,j,r)	Tax on intermediate use of domestic good i used in sector] in region r = DFTAX(i,j,r) / VDFM(i,j,r)
TFI(i.j.r)	Tax on intermediate use of imports of good i used in sector j in region r = IFTAX(i.j,r)/VIFM(i,j,r)
TPD(i.r)	Tax on private use of domestic good i in region r = DPTAX(i.r) / VDPM(i.r)
TPI(i.r)	Tax on private use of imports of good i in region r = IPTAX(i.r) / VIPM(i.r)
TGD(i.r)	Tax on government use of domestic good i in region r = DGTAX(i.r) / VDGM(i.r)
TGI(i.r)	Tax on government use of imports of good i in region r = IGTAX(i,r) / VIGM(i.r)

It will also be convenient to define aggregate tax rates for consumption taxes:

TF(i.j.r)	Average tax on intermediate use of domestic + import goods = FTAX(i,j,r) / VFIM(i,j.r)
TP(i.r)	Average tax on private use of domestic + import goods = PTAX(i.r) / VPM(i.r)
TG(i,r)	Average tax on government use of domestic + import goods = GTAX(i,r) / VGM(i,r)

4.2.4 Distribution of Sales to Regional Markets

The accounting relationships covered in this section trace tUe value flows of goods and services from production to consumption (or use as intermediates).

The Value of Output at Agent's prices (VOA) plus a Production tax (like all taxes, this is represented in accounting equations as tUe value of tax revenue) equals tUe Value of Output at Market prices (VOM):

$$VOA(i,r) + PTAX(i,r) = VOM(i,r) \tag{1}$$

For the supply equal to demand condition for any good, output must equal the sum of demands. In GTAP, this means that the Value of Output af Market prices equals the Value of the Domestic Market plus the Value of Services sold to the Transport sector plus the total Value of eXports at Market prices by Destination:

$$VOM(i,r) = VDM(i.r) + VST(i,r) + \Sigma_s\ VXMD(i,r,s) \tag{2}$$

The inclusion of export tax wedges means that tUe Value of eXports at Market prices Demanded by anotUer region plus a bilateral export tax wedge is equal to the Value of eXports at World (fob) prices:

$$VXMD(i,r.s) + XTAX(i.r,s) = VXWD(i,r,s) \tag{3}$$

The fob exports plus the Value of Transport services used in transportation at World prices is equal to tUe Value of Imports (to s) at World (c.i.f) prices:

$$VXWD(i,r,s) + VTWR(i,r.s) = VIWS(i,r,s) \tag{4}$$

The Value of Imports (to s) at World (c.i.f) prices plus an import tariff wedge is equal to the Value of Imports at Market prices in s:

$$VIWS(i,r,s) + MTAX(i,r,s) = VIMS(i,r,s) \tag{5}$$

The Total Value of Imports at Market prices is equal to the sum of Value of Imports at Market prices by Source. Here VIMS(i,s,r) is tUe value of imports of i from region s into destination region r:

$$VIM(i,r) = Z_s\ VIMS(i,s,r) \tag{6}$$

The Value of Imports at Market prices is also equal to the sum of the uses of imported goods: tUe Value of Imports for Private consumption plus tUe Value of Imports for Government consumpfion plus tUe total Value of Imports for use by Firms:

$$VIM(i,r) = VIPM(i,r) + VIGM(i,r) + \Sigma_j VIFM(i,j,r) \tag{7}$$

In addition, tUe Value of tUe Domestic Market referred to in equation 2 is equal to tUe sum of individual domesfic uses of tUe good, tUe Value of Domestic Private consumption plus tUe Value of Domestic Government consumption plus the sum of the Values of Domestic use by Firms:

$$VDM(i,r) = VDPM(i.r) + VDGM(i.r) + \Sigma_{\,\text{ı}}\ VDFM(i.j,r) \qquad (8)$$

4.2.5 Production

Producers in the GTAP model and database use inputs of factor services and intermediate goods to produce each produced commodity. Since these are the only inputs, and a zero-profit condifion is imposed, the Value of Output at Agents' prices must equal the Value of Firms' uses of intermediate inputs plus the Value of Firms' uses of factors:

$$VOA(j.r) = \text{I,}VFA(i,j,r) + \Sigma_f\ EVFA(f.j.r) \qquad (9)$$

Intermediate Inputs are composed of domesfic (VDFA) and imported (VIFA) components. For both these components, a tax exists so that values at Agents' prices equal Market price values plus tUe tax wedge:

$$VFA(i.j,r) = VDFA(i,j,r) + VIFA(i,j,r) \qquad (10)$$

$$VDFA(i,j.r) = VDFM(i,j,r) + DFTAX(i,j,r) \qquad (11)$$

$$VIFA(i.j,r) = VIFM(i.j.r) + IFTAX(i.j.r) \qquad (12)$$

Factor Services at Agents' prices equal tUe services at Market prices used in equation 9 above plus a tax wedge ETAX:

$$EVFA(f.j,r) = VFM(f,j,r) + ETAX(f,j,r) \qquad (13)$$

Factor services are collected by households, so that the Value of "Output" at (the households') Agents' prices of factor f is equal to the sum of tUe values of its uses in the j industries:

$$EVOA(f.r) = \text{S,}\ VFM(f,j,r) \qquad (14)$$

4.2.6 Regional Household Expenditure

Regional Expenditure is distributed among tUree types of spending: private, government and savings. Private and government expenditure is spent on eacU tradable good (altUougU some elements of tUese matrices may be zero):

$$EXPENDITURE(r) = \text{I,}\ [VPA(i,r) + VGA(i,r)] + SAVE(r) \qquad (15)$$

Private expenditure on eacU good in eacU region is split between domesfically produced and imported products:

$$VPA(i,r) = VDPA(i.r) + VlPA(i,r) \tag{16}$$

Both these products have taxes applied to them, so that the values at agents' prices are the inarket prices plus a tax:

$$VDPA(i,r) = VDPM(i,r) + DPTAX(i,r) \tag{17}$$

$$VIPA(i,r) = VIPM(i,r) + IPTAX(i,r) \tag{18}$$

Similarly, government expenditure is split between domestic and imported expenditure, with a tax applied to each:

$$VGA(i.r) = VDGA(i,r) + VIGA(i,r) \tag{19}$$

$$VDGA(i,r) = VDGM(i,r) + DGTAX(i.r) \tag{20}$$

$$VIGA(i,r) = VIGM(i,r) + lGTAX(i,r) \tag{21}$$

4.2.7 Regional Income

Regional income is comprised of two types of income: factor income and tax income. Equation 22 includes the factor income EVOA minus depreciation of capital VDEP, plus the revenues from the ten types of tax instrument.

$$\begin{aligned}
INCOME(r) = {} & \Sigma_f\, EVOA(f,r) - VDEP(r) \\
& + Z,\ PTAX(i.r) \\
& + \Sigma_i \Sigma_f\, ETAX(f,j,r) \\
& + Z,\ IPTAX(i,r) + Z,\ DPTAX(i,r) \\
& + Z,\ IGTAX(i.r) + Z,\ DGTAX(i.r) \\
& + Z,\ Z,\ IFTAX(i,j,r) + Z,\ \Sigma_i\, DFTAX(i,j.r) \\
& + Z,\ \Sigma_s\, XTAX(i,r,s) \\
& + \Sigma_i \Sigma_s\, MTAX(i.s.r)
\end{aligned} \tag{22}$$

In order to maintain balance, regional income from equation 22 must equal regional expenditure from equation 15:

$$INCOME(r) = EXPENDITURE(r) \tag{23}$$

4.2.8 Other GTAP accounting relationships

*The **International Transport Sector***

The GTAP database and model includes a treatment of international transport services, and as such, the payments to those services must be accounted for on both the expenditure (who pays for transport services?) and income (wUere do transport margins go?) sides. Equation 4 above included tUe value of services used in transport

VTWR(i.r.s), and equation 2 included a term for tUe value of services sold to tUe transport sector, VST(i,r). Since the GTAP database lacks the data to link these arrays directly, transport services are collected in a global transport service. The value of global transport services is GLOBTRAN:

$$GLOBTRAN = \Sigma_i \Sigma_r \Sigma_s VTWR(i,r,s) \quad (24)$$

$$GLOBTRAN = Z, Z, VST(i,r) \quad (25)$$

Savings ***and Investment***

The GTAP database includes data for regional investment and savings, but lacks data on the bilateral international investment, so for the purpose of the GTAP model, savings from all regions are assumed to be equal to global investment:

$$GLOBINV = \Sigma_r [REGINV(r) - VDEP(r)] \quad (26)$$

$$GLOBINV = \Sigma_r SAVE(r) \quad (27)$$

Regional investment comprises the purchase of all tradable commodities to make a regional capital good, which is non-traded.

$$REGINV(r) = VOM(\text{"cgds"},r) \quad (28)$$

where "cgds" refers to the set element (of produced commodities]) for capital goods.

4.3 GTAP DATABASE LIMITATIONS

The amount of data needed in a global CGE modelling framework is extremely large, and it is inevitable that such an ambitious project as GTAP has its limitations. WUile most of tUe limitations mean tUat tUe database is not well suited to certain issues, others mean that even for trade studies (the use that the database was intended for, and is best suited for) it has some short-comings.

4.3.1 General Limitations

The amount of work required to construct a database that would be required for appropriate detail in certain areas is often prohibUive; in some cases the data are unavailable, and thus not covered by GTAP. The areas in question, the simplifications they impose and any special limitations they imply (other than a reduction in the accuracy of simulations) are discussed below.

4.3.2 Regions

In order to make the database and model global, all countries must be included, which requires the inclusion of aggregate regions. TUe six aggregate regions in tUe full database (Rest of Latin America. Sub SaUaran Africa, Middle East and North Africa, Economies In Transition, South Asia, and Rest of World) must involve inaccuracies, mainly because the collection of full input-output tables and expenditure data for all countries is prohibitively costly and often impossible. These regions are each extrapolated from one or two "typical" countries within the region. altUougU some data (trade data, macro aggregates) are available for all countries. Because of tUese inaccuracies, tUe GTAP data are inappropriate for examining tUe effects of policy experiments specific to tUe aggregate regions.

The EU is not defined as one of the six aggregate regions because it is considered to be a single country with a single trade policy. Unfortunately, this means that we are unable to identify the effects of CAP reform and/or the Uruguay Round on individual members.

Version 4 of the GTAP database used in Chapters 7 and 8 has a slightly more disaggregated database, with 45 regions including four EU countries (the UK, Germany. Denmark and Sweden) and an aggregate `Rest of the EU" group.

4.3.3 Sectors

As with the database regions. the main limitation tUat tUe sectors defined in tUe database imposes is wUen sectors pertinent to a particular issue are not defined separately. TUe 37 sectors tUat tUe database defines are usually sufficient for most analyses, but more sectoral disaggregation would always add more accuracy to tUe simulation and tUe simulation results. TUe version four database used in CUapters 7 and 8 has 50 sectors.

4.3.4 "Missing" Data

Few databases include all data that users might need, and GTAP is no exception. Short-comings in the available data are:

- Links between the private households and government (income taxes, other taxes and transfers) are not included. The regional household limits the applicability of GTAP for fiscal reform simulations.

- The absence of data on different households within each region limits the ability of GTAP to model the effects of scenarios on income distribution.

- GTAP includes no bilateral ownership data on capital. The "global savings bank"" inakes GTAP unsuitable for the analysis of international capital flows, and leads to the inconsistency that existing capital in region r is owned wholly by agents in region r, while investment in region r comes from all regions.

- Links between tUe use of transport services and tUeir source are not included. TUe global transport service may lead to some small inaccuracies in results, and ignores any restrictions on sourcing of transport services.

- Bilateral trade and protection data by good and by use is not included. GTAP includes bilateral trade and protection data by good, but tUe full matrix is proUibitive in size. TUis presents problems particularly for the highly aggregate cominodities (i.e. Other Manufacturing) where private demand uses particular types of these goods while intermediate demand may be for other types. In developing countries for example, private demand for Other Manufacturing is likely to be composed of "Luxury" goods, often with high tariffs, while intermediate demand may be for office equipment and a variety of (non Machinery) goods that are used in production. The tariff structure of goods for private and intermediate demand will often be different, and the sourcing of imports may also be different.

- The values specified for the elasticity parameters in the functional forms used are not accurately estimated. Most elasticities are assumed to be the same for good i across all regions, and are taken from parameters originally estimated from the Australian SALTER model in the 1970s.

4.4 GTAP DATABASE ADVANTAGES

The main advantage that the GTAP database has is its sheer size and coverage. Such a database would take any researcher years to construct separately, so the availability of the database for public sale is a major bonus for modellers.

4.4.1 Database Expertise

Apart from the data itself, a major bonus tUat the GTAP database brings is tUe database-building expertise of tUe various members of tUe GTAP consortium wUo have contributed data to the database and have continued to work with the data. In particular, apart from the staff at the IMPACT project in Australia and the GTAP staff at Purdue, the USDA, GATT/WTO and the OECD economics division have all been major contributors, and have for instance developed particular techniques for consolidating bilateral trade and trade protection data.

4.4.2 Input-Output Data

The input-output data in the GTAP database are unique in that they are constructed using the same commodity concordances in a large-scale global setting. While tUis cannot be done for all countries in tUe same year, tUe years tUat tUe database I-O tables are derived from are close enougU to be as accurate as could be Uoped for in sucU a large-scale database, and are updated to 1992 (1995 in tUe case of version 4) to enable them to be a common database.

4.4.3 Bilateral Trade data

Global-wide bilateral trade data are very rare and, as noted above, certain techniques have already been used to consolidate them. TUe main problem with unconsolidated data is that countries tend not to be particularly diligent when constructing trade data (although some countries are better than others). This means that any two countries may report different volumes of trade for a particular commodity: for example, Brazilian statistics might say that Brazil exports 100 million tonnes of Coffee to Canada, but Canadian statistics migUt say tUat Canada imports 150 million tonnes from Brazil. SucU problems become marked in Sub-SaUaran Africa and otUer low-income LDCs, wUicU may not report mucU trade at all. Import statistics tend to be more reliable on tUe whole because governments keep records of imports for tUe purpose of levying tariffs, while exports are often poorly recorded unless they are taxed or subsidised. Where countries give tariff exemptions, for example to some industries, or to Export-Processing Zones, and to imports that are exempt from tariffs because of Customs Union membership, even imports are often not recorded. In Eastern Europe and the former Soviet Union, the problems of trade reporting enter into different realms altogether, with barter trade, non-reporting and black inarket activity often leading to the reporting of zero trade flows where large flows are known to exist.

To attempt to obtain some meaningful data from the quagmire of under-reporting (and non-reporting), GTAP data are consolidated using a table system performed separately for each country"s imports and exports. A 'mark' is given to each country, derived from the differences between its reported trade and its partners" reports of the same trade flows. The countries that tend to have low differences are then assumed to be 'better' reporters of trade than countries that have high differences with their trade partners. A league-table is constructed, and the ten "best" export reporters and the ten 'best' import reporters at this stage are used as a control group, and a reliability index is constructed by assessing what proportion of each country's reported trade flows with the control group are accurately reported.

The final trade flow values that are used in the database are derived as a weighted average of the two partners" reported trade, with the reliability index used to obtain weights. Where one partner has obtained a much higher reliability score than the other, the unadjusted trade flow reported by the better partner is used.

This whole procedure is conducted at a 4-digit Standard Industrial Trade Classification (SITC) level for each individual country and then aggregated to the GTAP concordances. TUe resulting trade flows tUen undergo a matrix-balancing procedure in order to ensure that total exports/imports for eacU region meet defined totals, with weights ensuring tUat trade flows between "good reporting' countries are not changed as much as trade flows between "poor reporting" countries.

Table 4-4 The Five Best and Worst Export Reporting Accuracy Rates.

	Export Reporters	*Percent Accuracy*
1	Faeroe Islands	52.24
2	Germany (united)	52.07
3	Angola	.50.00
4	Austria	45.93
5	France	45.79
96	Cameroon	16.82
97	Kiribati	16.67
98	Ethiopia	16.36
99	Oman	16.23
100	Togo	16.07

Source: GTAP short course notes (from Mark Gelhar. ERS of the USDA)

4.4.4 Bilateral trade protection data

Trade protection data are taken largely from GATT submissions - in other words, those tariffs and other protection instruments that countries declare to GATT. TUe provision of tUese data on a bilateral commodity-specific basis is a large bonus from the GTAP database. Any other border protection that countries apply is not included, and in the case of import surcharges this may be a serious problem. Francois *et al.* (1995, p.3) outline this as follows:

> *"Customs surcharges and fees are tariffs under another name (hut sometimes with a different justification) and can add substantially to protection. Indeed, examples where surcharges add 50% or more to the basic tariff rates arc not uncommon."*

4.5 GTAP DATABASE PARAMETERS

Section 4.5 examines the GTAP database, with particular attention paid to key parameters. TUe source for all data is tUe GTAP version 2 database.

4.5.1 Income

Figure 4-1 demonstrates tUe importance to tUe world economy of tUree economies - the USA, Japan and tUe EU, wUicU togetUer account for 71% of world income. TUe EU is tUe world's largest single market in income terms, while tUe USA is the largest-earning single country, and NAFTA is the largest trade block. Table 4-5 confirms this, and gives income figures from the GTAP database for each of the 24 disaggregate GTAP regions.

4.5.2 Output

Figure 4-2 demonstrates the importance of services, accounting for a total of 57% of world output. Agriculture and food processing together account for just over one tenth of world output.

Figure 4-1: World Income by Country/Region

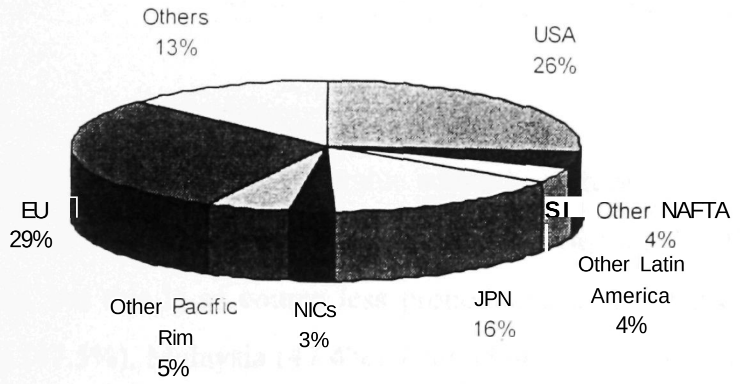


Table 4-5: Regional income (USSbn)

	Dollar income	% of world income		Dollar income	% of world income
AUS	256.89	1.27	CHN	447.43	2.22
NZL	35.87	0.18	HKG	17.84	0.09
CAN	525.16	2.60	TWN	212.17	1.05
USA	5257.06	26.05	ARC	198.92	0.99
JPN	3166.76	15.69	BRA	334.12	1.66
KOR	268.54	1.33	ME.X	293.62	1.46
E_U	5863.29	29.06	LAM	219.69	1.09
IDN	118.93	0.54	SSA	147.99	0.73
MYS	60.24	0.30	MNA	512.00	2.54
PHL	48.92	0.24	EIT	731.45	3.63
SGP	27.32	0.14	SAS	298.94	1.48
THA	99.06	0.49	ROW	1035.77	5.13

Figure 4-2: The Structure of World Output

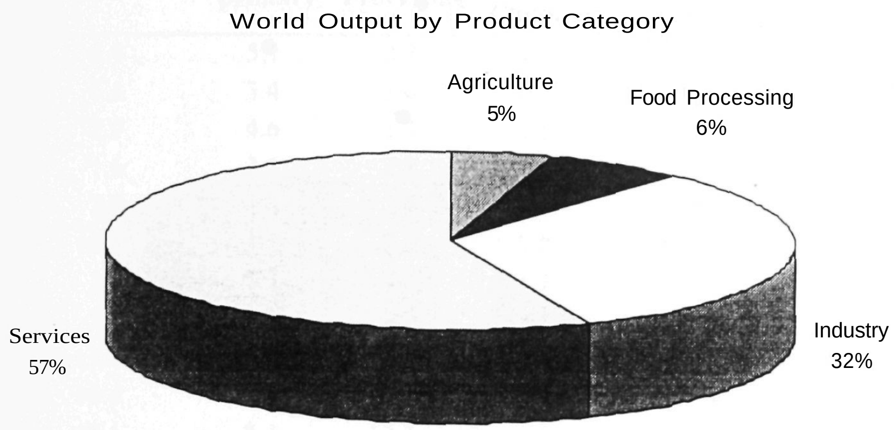


Table 4-6 shows the structure of value added in each region, with sectors aggregated into the broad categories defined in section 4.1.1. Services are the dominant sector in all regions, but this is of course less pronounced in developing countries, where in Indonesia (47.5%), Malaysia (47.4%), China (34.2%), South Asia (33.3%), Argentina (46.9%) and Sub-Saharan Africa (37.6%) services account for under half of total value added. Value added in resource-based manufactures is higher than in final manufactures in all regions except Japan, Hong Kong and Malaysia. Similarly, value added in agriculture exceeds value added in food processing in all regions except the USA and EU. Five regions stand out as having large "'other"' primary sectors - Indonesia (16.5% of value added), Malaysia (18.5%), Latin America (10.1%), Sub-Saharan Africa (18.6%) and the Middle East and North Africa (21.2%). Textiles and clothing is a minor sector in all regions: Hong Kong is the only region where it contributes over 5% of total value added.

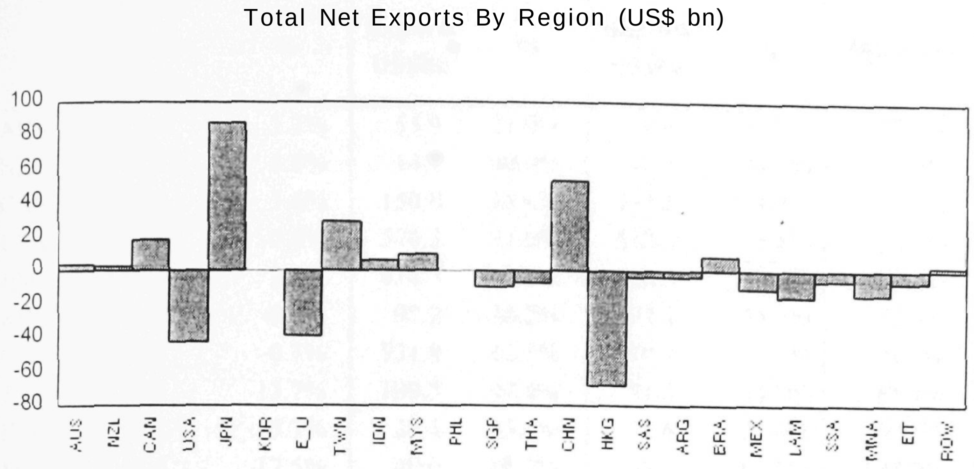
Table 4-6: Structure of Value Added (percentages of total regional value added)

	Agriculture	Other primary	Food Processing	Textiles and Clothing	Resource-based manufactures	Final manufactures	Services	All Goods
AUS	5.9	5.1	2.7	1.1	7.0	4.0	74.2	100.0
NZL	6.4	3.4	5.0	0.9	8.9	3.7	71.8	100.0
CAN	2.9	4.6	3.2	1.5	9.9	9.7	68.1	100.0
USA	1.6	3.1	2.3	1.0	8.3	9.4	74.3	100.0
JPN	2.9	1.6	2.4	1.2	9.8	13.1	69.0	100.0
KOR	10.7	3.7	2.3	2.2	12.1	10.0	59.0	100.0
E_U	3.8	2.3	4.2	1.7	10.5	8.9	68.7	100.0
TWN	5.2	4.3	2.3	3.2	15.9	11.4	57.6	100.0
IDN	17.9	16.9	3.4	1.9	10.1	2.4	47.5	100.0
MYS	10.4	18.5	2.5	1.1	7.5	12.5	47.4	100.0
PHL	17.1	8.4	10.3	1.8	5.3	2.5	54.7	100.0
SGP	0.7	0.3	1.2	0.7	19.3	16.8	61.0	100.0
THA	10.7	6.9	6.8	4.9	7.7	6.9	56.1	100.0
CHN	30.6	7.7	3.2	4.5	11.4	8.4	34.2	100.0
HKG	0.6	1.4	1.7	7.6	3.5	8.7	76.6	100.0
SAS	36.0	7.1	3.7	3.9	9.5	6.5	33.3	100.0
ARG	10.8	6.8	8.9	4.4	15.4	6.9	46.9	100.0
BRA	9.1	3.5	4.5	2.9	14.6	8.4	57.0	100.0
MEX	9.5	6.0	6.6	2.0	9.8	5.6	60.5	100.0
LAM	13.3	10.1	5.8	3.2	10.5	3.9	53.1	100.0
SSA	24.2	18.6	4.8	2.2	8.5	4.0	37.6	100.0
MNA	7.3	21.2	3.1	1.6	7.2	3.3	56.3	100.0
EIT	4.3	4.4	3.5	1.7	10.0	7.8	68.2	100.0
ROW	3.6	4.0	2.7	1.7	10.5	9.7	67.7	100.0

4.5.3 Global Trade and Protection

Figure 4-1 shows net exports by region (including sales to the global transport sector). Three bilateral trade flows account for the largest trade surpluses and deficits: The large bilateral trade surpluses that Japan has with the US and the EU largely account for both Japan's large overall trade surplus and the US's and EU's trade deficits. Similarly, a large Chinese bilateral trade surplus with Hong Kong is evident in the database, and accounts for both a large Chinese trade surplus and a large Hong Kong trade deficit. This is less of a long-term feature, and occurs because much of Chinese trade (particularly in textiles and clothing) passes through Hong Kong to final markets, particularly those in the EU and US. This happens largely because China has lower MFA quotas than Hong Kong, as when the MFA system was set up China

Figure 4-1: Net Exports



exported very low quantities of clothing and textiles, and Hong Kong was a major exporter.

In 1992 Hong Kong imported large quantities of clothing from China that it did not re-e.xport until the following year, and hence the trade that is really passing through Hong Kong shows up in the GTAP database as a large trade deficit.

Table 4-7 shows more detailed figures for net trade in each region, including the trade balance as a percentage of income (GDP). Here it is apparent that the trade deficits of the USA and EU are actually small as a percentage of income, -0.8% and -0,7% respectively. Other countries, such as Singapore (-33,8%). Other Latin America (-7,2%) and Thailand (-6,6%) have larger trade deficits as a percentage of income. The Hong Kong trade deficit is not only the largest in dollar terms, but also the largest as a percentage of income (-382,2%).

The 'Openness' column in Table 4-7 shows imports plus exports as a percentage of income, an indicator widely used to assess a country's openness to trade. Larger countries such as the USA, Japan and EU have low openness statistics (22.7%, 23.4% and 25,6% respectively) as larger economic markets tend to be more self-sufficient. Hong Kong has a very high (and distorted) openness statistic, because of the China-Hong Kong trade noted above, but Singapore and Malaysia both have openness statistics greater than 100%,

Table 4-7: Trade Figures (USSbn and percentages of income)

	Trade Balance USSbn	%	Exports USSbn	%	Imports USSbn	%	Openness	Income USSbn
AUS	3,3	1,3%	53,9	21.0%	50,6	19.7%	40.7%	256,9
NZL	2,4	6,8%	14.7	40.9%	12.2	34.1%	75,0%	35,9
CAN	19.0	3.6%	150.0	28,6%	131.0	24.9%	53,5%	525,2
USA	-42,5	-0.8%	576,3	11.0%	618.9	11.8%	22.7%	5257.1
JPN	88,4	2.8%	414,7	13.1%	326,3	10.3%	23.4'",,	3166.8
KOR	-0.2	-0.1%	97,2	36.2%	97,4	36,3%	72.4'",,	268,5
E_U	-38.7	-0.7%	731.8	12.5%	770,4	13,1%	25,6%	5863,3
TWN	29.0	13.7%	100,5	47.4%	71,5	33,7%	81.1%	212,2
IDN	6.8	5.7%	39,4	33.1%	32,6	27,4%	60,5%	118.9
MYS	10.6	17.5%	49,0	81.3%	38,4	63,7%	145.0%	60,2
PHL	0.3	0.5%	17,3	35,3%	17,0	34,8%	70,0%	48,9
SGP	-9,2	-33.8%	78,2	286.2%	87,4	320,0%	606,2%	27.3
THA	-6,5	-6.6%	37,9	38.2%	44,4	44,8%	83.0%	99.1
CHN	53.3	11.9%	141.7	31.7%	88,4	19.8%	51.4%	447.4
HKG	-68,2	-382.2%	73,3	410.8%	141.5	793,0%	1203.7%	17.8
SAS	-3.5	-1.2%	39,4	13.2%	42.9	14.4%	27,6%	298.9
ARG	-3.0	-1.5%	16,2	8.1%	19.2	9,6%	17,8%	198.9
BRA	9.1	2.7%	42,0	12.6%	32.9	9.9%	22.4"/o	334.1
MEX	**-11.1**	-3,8%	57.5	19,6%	68.6	23,4%	42,9%	293.6
LAM	-15.8	-7,2%	76.4	34.8%	92.2	41.9%	76.7%	219.7
SSA	-5.3	-3,6%	43.4	29,3%	48.7	32.9%	62.2%	148.0
MNA	-14.5	-2,8%	167.8	32,8%	182.3	35,6%	68.4%	512.0
EIT	-6,6	-0,9%	84,7	11.6%	91.3	12.5%	24.1%	731.5
ROW	2,9	0,3%	335.3	32.4%	332.4	32.1%	64.5%	1035.8

Table 4-8 shows average protection levels. The four columns show average import tariffs and export taxes, both as applied by the country in question. and applied by trading partner countries. The EU for example, applies an average 8.32% import: tariff on its own imports - a level that is relatively low in comparison to other countries. Meanwhile the EU faces an average 9.67% import tariff in foreign markets on its own exports. It applies an average 3.48% export tax, and its imports bear on average a 2.62% export tariff applied by its export suppliers.

Eleven countries apply import tariffs between 8% and 10%, with another eleven countries applying higher rates than 10%. The highest average import tariff is in Thailand (33.10%), with China (30.35%), Korea (24.83%), Brazil (23.47%) and The Philippines (21.79%) also standing out as high-tariff countries. Singapore and Hong Kong both apply very low tariffs.

Argentina faces the highest tariffs applied by trading partners on its exports (24.20%), with Hong Kong (19.48%), New Zealand (17.15%) and Japan (15.15%) also facing high tariffs applied by partner countries on their exports. Table 4-9 shows that the highest levels of tariff protection in industrial countries occur in agricultural goods and food products, with the exceptions of Australia. New Zealand and the USA which applies its highest tariff to Textile and Clothing.

There is much variation in the structure of protection in developing countries, from Japanese-style agricultural protection in Korea and Taiwan (with low tariffs for manufactures), high levels of protection in all (or most) sectors in Thailand, Argenfina and Brazil to low levels of protection in all sectors in Hong Kong and Singapore. Many developing countries apply higher tariffs to textiles and clothing than do the developed-country MFA importers.

Table 4-8: Average import tariffs and export taxes, by importers and exporters

	Import Tariffs		Export Taxes	
	Applied by importer	Faced by exporter	Faced by importer	Applied by exporter
AUS	12.91	12.36	0,52	0.52
NZL	17,69	17.15	0.42	1.30
CAN	8,76	6.43	1.41	-0,36
USA	8,74	11.46	3,04	-0.18
JPN	13.03	15.15	0,40	1.12
KOR	24.83	8.86	0.19	1.21
E_U	8.32	9,67	2,62	3,48
IDN	13.59	8,44	0,80	5,16
MYS	8.24	7,64	0.11	11.37
PHL	21.79	12,69	-0,12	5,53
SGP	0.41	8.22	1,99	0,33
THA	33.10	11.47	0,56	2.58
CHN	30.35	10.08	-0.01	4,58
HKG	0.00	19,48	0,36	2,29
TWN	10.53	11.45	0,42	0,99
ARG	18.57	24.20	0,60	0,00
BRA	23.47	13.66	0,68	0,98
MEX	9.80	4.94	-0,02	0,61
LAM	9.56	10.84	0.31	2.10
SSA	8.38	8,32	1.03	0.16
MNA	8.16	3,42	0,74	0,16
EIT	8.39	8,08	0.35	2.07
SAS	7,42	11.26	2.14	11.62
ROW	8.44	6,84	3.07	0.91

The export tax data are dominated by two considerations: MFA voluntary export restraints on textiles and wearing apparel, and developed country agricultural export subsidies. The MFA VERs lead to high *ad valorem* equivalents for export taxes from developing countries on exports of textiles and wearing apparel to the USA, EU. Canada and the Rest of the World (ROW) - because the ROW group includes non-EU Western Europe, which for 1992 encompasses countries that are MFA importers such as Sweden and Austria.

Table 4–10 shows the average export taxes applied by each region in major coinmodity groups, and demonstrates several features. The only regions that on average apply export subsidies to agriculture and food are Canada. the USA, the EU

Table 4-9: Average import tariffs applied by importer

	Agriculture	Other primary	Food Products	Textiles and Clothing	Resource-based manufactures	Final manufactures	Services	All Goods
AUS	6.8	0.4	7,3	13.5	14.7	18.8	0,0	12,9
NZL	3.3	0.5	I1.9	32,6	18.0	29.5	0.0	17.7
CAN	23.2	0.1	13.9	21.3	9,7	8.5	0.0	8,8
USA	11.6	0.7	I1.2	18.4	7,1	11.6	0.0	8,7
JPN	200,3	1.4	36,3	11.9	4,6	3.5	0.0	13.0
KOR	233,9	5.4	36.5	18.3	14.3	19.0	0.0	24.8
E_U	55,6	1,0	25,0	12.7	8,0	8.7	0.0	8.3
TWN	142.3	1,9	26.7	6,8	3.4	8.0	0.0	10.5
IDN	43.5	1.7	18.4	28.3	7,6	16.5	0.0	13.6
MYS	1.3	2,5	7.7	22.3	7,0	9.2	0.0	8.2
PHL	21.0	18,4	24.5	39.8	19.9	23,6	0.0	21.8
SGP	0.0	0,0	0.1	0.5	1,7	0.1	0,0	0.4
THA	43.2	26,1	46.6	59.5	24.8	38.4	0,0	33.1
CHN	11.2	11.4	37,9	65.9	19,7	34,8	2.2'	30.4
HKG	0.0	0,0	0,0	0.0	0,0	0,0	0,0	0.0
SAS[2]	8.8	4.1	11.4	13.2	8,6	11,5	0,0	7.4
ARG	17.5	16,2	17.4	36.9	19,3	24,6	0.0	18.6
BRA	12.7	1,0	41.6	62.4	29,5	41.2	0,0	23.5
MEX	8.1	8,5	7,3	16.9	8,7	12,5	0.6	9.8
LAM[2]	10.5	9.1	12,5	14.8	9,8	11.9	0,0	9.6
SSA[2]	8.5	6,7	11.9	12.6	9,5	11.7	0.0	8,4
MNA[2]	8.8	5.2	11.9	12.9	10.2	11.3	0.0	8,2
EIT[2]	9.8	2,5	11.9	12.5	10.3	11.1	0,0	8,4
ROW[2]	9.3	3,8	11.1	12.5	10.4	11.3	0,0	8,4

[1] The only service protection data in the database is a small import tariff on Chinese imports of electricity from H Kong,

[2] One feature of the database is that the six aggregate regions all have broadly similar tariff structures.

and Brazil. These subsidies are far higher in the EU than elsewhere. Australia subsidises exports of food, but it taxes agriculture. Malaysia stands out as a country that applies significant export taxes on most sectors, including agriculture. Comparison of the Malaysian data in Table 4-10 and Table 4-11 shows that the average export tax for Malaysian textiles and clothing (75.1%) is much higher than the *ad valorem* equivalent of MFA quotas on Malaysian exports. Malaysia therefore is taxing exports of textiles and clothing (to all destination regions) in addition to the VERs.

Table 4-10: Average export tax/subsidy applied by exporter

	Agriculture	Other primary	Food Processing	Textiles and Clothing	Resource-based manufactures	Final manufactures	Services	All Goods
AUS	1.2	1.3	-1.5	-0,4	1.3	-0.5	0.1	0.5
NZL	0.9	0.3	1.6	6,9	1.0	0.9	1.7	1.4
CAN	-6.1	0.0	-1.6	0,0	0.0	0.0	0.0	-0.3
USA	-3.3	0.0	-0.9	0,0	0.0	0.0	0.0	-0.2
JPN	0.0	0.0	0,0	0,0	0.6	1.4	0.0	1.0
KOR	0,0	0.0	0,0	7,6	0.0	0.2	0.0	1.2
E_U	-30,2	1.9	-1,5	0,2	15,4	0,9	-0.5	2.8
TWN	0,0	0.0	0,0	7,6	0,2	0,0	0.0	1.0
IDN	0,0	0.0	0,0	33,2	0,1	0,0	0.0	5.0
MYS	16,2	11.5	12,4	75,1	13.3	3,0	8.2	11.3
PHL	0,0	0.0	0,0	37,5	0.0	0,0	0,0	4.5
SGP	0,0	0.0	0,0	8,9	0.0	0.0	0,0	0.3
THA	0,0	0.0	0,0	20,2	0.1	0.0	0,0	2.6
CHN	0,0	0.1	0,0	17.9	0.4	0.0	0,0	4.5
HKG	0,0	0.0	0,0	9,3	0.0	0.0	0,0	2.2
SAS	0,0	0.0	0,0	35.0	0.4	0.2	0,0	11.6
ARG	0,0	0.0	0,0	0.0	0.0	0.0	0,0	0.0
BRA	-2,2	4.0	-0,6	11.0	2.1	-1.1	0.1	1.0
MEX	0,0	0.0	0,0	17.8	0.0	0.0	0,0	0.6
LAM	0,6	0.2	7,2	19.3	0.4	-0.3	0,0	2,1
SSA	0.1	0.0	1.4	0.0	0.5	0.1	0,0	0,2
MNA	1.9	-0.6	2,1	8.5	1.0	0.2	0.1	0,2
EIT	0.8	0.3	5,7	10.9	1.8	1,3	0,9	2,1
ROW	1.6	0.1	7,1	5.2	1.3	0,2	0,0	0.9

Table 4-11: *Ad valorem* export tax equivalents of MFA quotas

	Textiles			Clothing		
	CAN	USA	E_U	CAN	USA	E_U
KOR	9.63	9.85	10.09	19,54	23,33	19.37
IDN	17.50	11.95	17.46	41.13	46,74	48,37
MYS	15.17	9,50	11.70	35,66	37.14	32,40
PHL	11.52	8,57	10,03	27,08	33.52	27,79
SGP	11.89	7,93	10.10	27,94	31.01	27.98
THA	13.71	9,07	12.85	32,23	35,46	35,58
CHN	23,21	18.41	27,35	42,00	40,32	36.11
HKG	7,63	7,67	8.10	15.49	18.19	15.55
TWN	9,43	8,16	11.64	19.15	19.35	22,35
BRA	11.61	9,21	13.68	21,00	20,16	18.06
MEX	11.61	9,21	13.68	21.00	20.16	18.06
LAM	11.61	9,21	13.68	21.00	20,16	18.06
MNA	5.80	4,60	6,84	10.50	10,08	9,03
EIT	7,74	6,14	9.12	14.11	13.44	12,04
SAS	23.21	18.41	27,35	42,00	40,32	36.11
ROW	4.64	3,68	5,47	8,40	8,06	7,22

source: GTAP short course notes

4.5.4 Trade and Agricultural Protection by GTAP Region

This section concentrates on each GTAP region in turn, examining the trade position and agricultural protection for that region.

Australia

Figure 4-1 shows the Australian net trade position arranged by GTAP sector, and it is clear that Australia's net exporting sectors lie to the left of the graph in agricultural, other primary, and food processing industries. The main net importing sector is other machinery and equipment (OME), followed by transport industries (TRN). Australia exports 68% of world wool trade.

Table 4-12 presents the structure of Australian agricultural protection, which shows a generally low level of protection; only milk and milk products (MIL) has rates above 10%. Support in the main agricultural goods (the first six rows, as opposed to food processing) consists of small output subsidies and small import tariffs.

Figure 4-1: **Australian** Net **Exports**

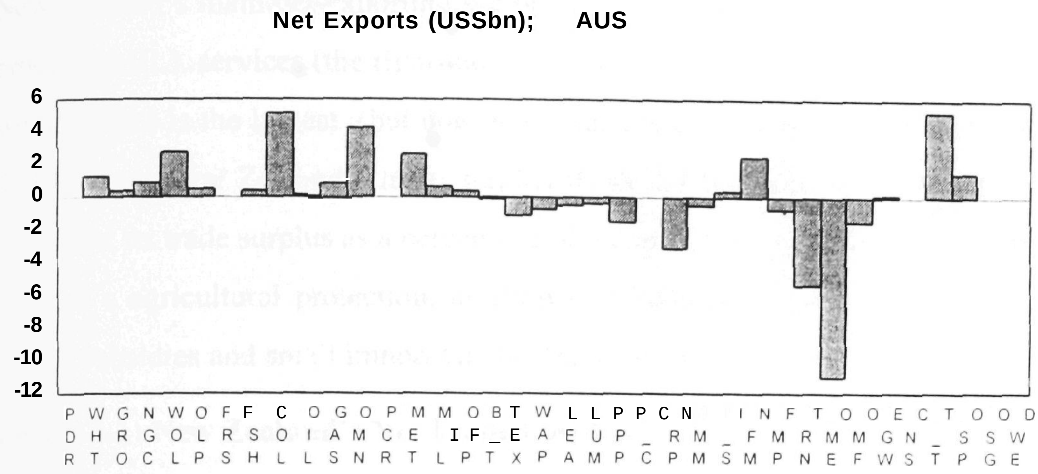


Table 4-12: The Structure of Australian **Agricultural** Protection

	Output Subsidy Expenditure $million	Output Subsidy Rate %	E,\port Subsidy E.xpenditure $million	Export Subsidy Rate %	Import Tariff Revenue Smillion	Import Tariff Rate %
PDR	4.43	3.70			0.01	4.40
WHT	70.97	4.09			0.00	0.20
GRO	24.49	3.50			0.04	1.89
NGC	145.13	2.20	0.30	0.03	26.74	8.70
WOL	107.93	3.28			0.60	2,00
OLP	93,49	1.30			1.44	1.75
PCR					0.71	**4,40**
MET					2.77	8.04
MIL			136.08	16.75	36.03	34.00
OFP					50.00	4.40
B_T					27.61	8.67
ALL	455,44	0.89	136.47	1.15	148.06	6.68

New Zealand

New Zealand's main net-exporting sectors arc processed foods (meat. MET and milk products MIL). services (the right-most six columns) and agricultural goods. of which wool (WOL) is the largest (but docs not dominate agricultural net cxport.s). While in dollar terms New Zealand's trade surplus ((IS$ 2,4 bn) is small compared to other countries. its trade surplus as a percentage of income (6.8%) is one ot the largest. New Zealand's agricultural protection. as shown in fable 4-13. consists entirely of low output subsidies and small import tariffs. Export subsidies are not used at all.

Figure 4-1: New Zealand's Net Trade Position

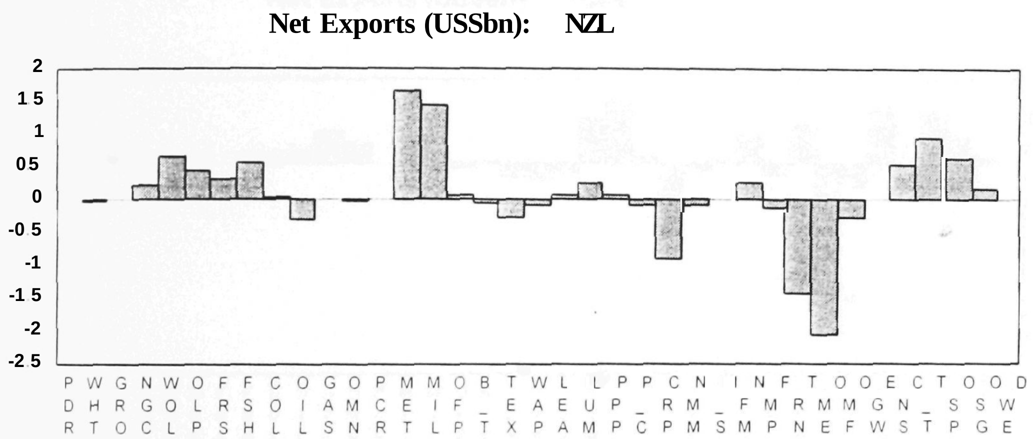


Table 4-13: The Structure of New Zealand's Agricultural Protection

	Output Subsidy E.xpenditure Smillion	Output Subsidy Rate %	Export Subsidy Expenditure $million	Export Subsid)' Rate %	Import Tariff Revenue $million	Import Tariff Rate "/o
PDR						
WHT	1.02	2.70				
GRO	2,06	1.00			0.09	1.30
NGC					5.06	4.50
WOL	25,98	1.99				
OLP	47,47	1.50			0.00	3.00
PCR						
MET					2.71	15.20
MIL	14.45	0.80			0.89	10.60
OFP					54.70	15.30
B_T					0.00	0.00
ALL	90.99	0.62			66.63	9.13

Canada

Canada has an overall trade surplus of US$19 bn, with a variety of sectors being net exporters. from agricultural (wheat. WHT) and primary fuel industries. wood-based industries (lumber. LUM and pulp paper products PPP). some manuiacluring industries and services. The striking feature of Canada's trade pattern is the large trade deficit in the other machinery and equipment (OME) sector.

Canada's agricultural protection (Table 4–14) uses a combination of all three support t\pes. By dollar \alue. output subsidies are the most extensive measure of support - although it should be remembered that import tariffs can have a far greater effect than

Figure 4-2: Canada's Net Trade Position

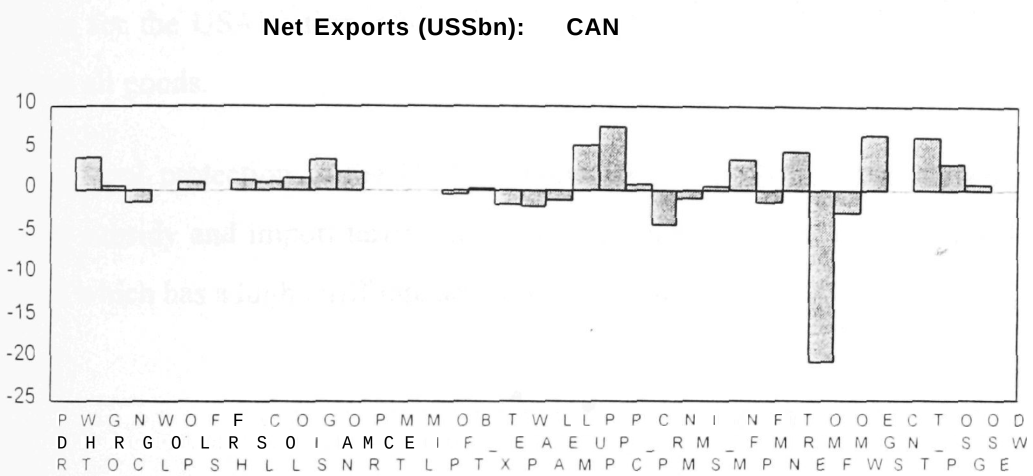


Table 4-14: The Structure of Canadian Agricultural Protection

	Output Subsidv Expenditure Smillion	Output Subsidy Rate %	Export Subsidy Expenditure Smillion	Export Subsidy Rate %	Import Tariff Revenue $million	Import Tariff Rate %
PDR						
WHT	800.13	16.80	304.61	7.10	0.04	28.80
GRO	232.71	7.60	114.01	15.08	14.57	14.50
NGC	006.00	10.30	64.04	4.99	607.63	23.78
WOL	0.07	3.47			0.10	2.30
OLP	679.87	4.70			59.60	21.90
PCR					0.07	LOO
MET	2310.09	21.90			187.43	21.90
MIL	355.51	4.50	123.60	44.06	177.23	135.40
OFP			7.74	0.29	219.44	7.00
B_T					92.05	13.51
ALL	5297,06	5.67	614.89	4.28	1360.49	16.01)

the revenue raised - a large tariff will raise incomes in the import competing sector as imports are brought down lo low le\eLs. which ma\ mean low levels of tariff revenue.

The Canadian tariff rate on Milk and Milk Products (MIL) al 135.40%. is the largest tariff rate. and this sector also benefits from a large (44.06%) export subsidy. and a *4.5%* output subsidy.

The USA

The USA has an overall trade deficit of US$ 43 bn in the GTAP database. with several sectors being major net importers: oil. wearing apparel (WAP). leather goods (LEA) transport equipment (TRN). other machinery and equipment (OME) . other manufacturing (OMF) and electricity gas and water (EGW). The dominant trade pattern for the USA is that it is a major exporter of services. and a net importer of almost all goods.

Agricultural protection in the USA is dominated by output subsidies. with smaller export subsidy and import tariff rates. with the exception of Milk and Milk Products (MIL) which has a high tariff rate and low output subsidy rate.

Figure 4-1: The United States' Net Trade Position

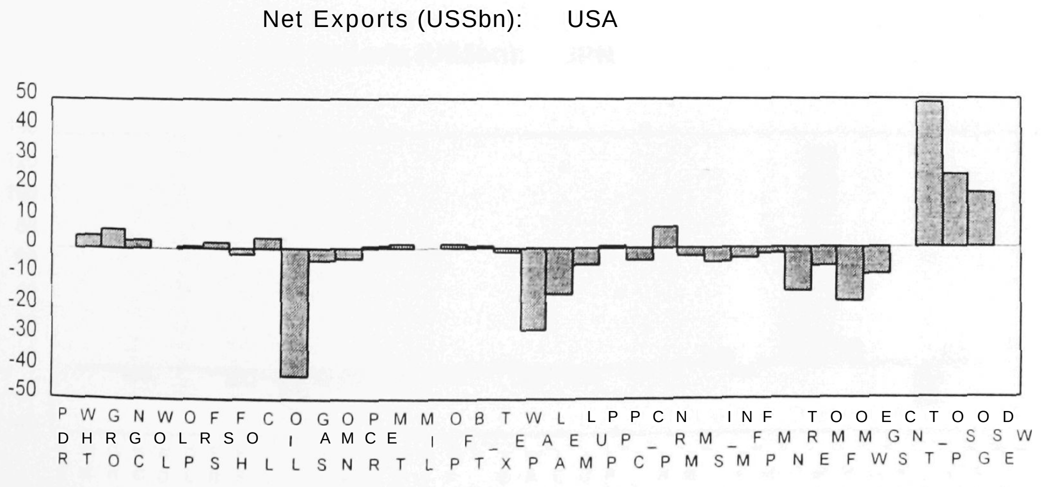


Table 4-15: The Structure of American Agricultural Protection

	Output Subsidy Expenditure Smillion	Output Subsidy Rate %	Export Subsidy Expenditure Smillion	Export Subsidy Rate %	Import Tariff Revenue Smillion	Import Tariff Rate %
PDR	1361.28	57,30	18.37	5.83	0.19	1.45
WHT	5543.34	32.40	845.84	16.70	20.27	10.10
GRO	10472.71	30.60	84,02	1.28	0.82	3.50
NGC	3617.33	5.20	0.28	0,00	901.06	10.57
WOL	01.32	63.00			8.84	5.10
OLP	3268.00	3.50			358.30	18.20
PCR					5.31	4.80
MET			69.00	1,53	572.01	18.20
MIL	1972.92	4.30	212.47	34.10	514.39	00.80
OFP					633.87	7.20
B_T					330.65	5,84
ALL	26326.00	3.76	1229.98	2.28	3429.02	9.86

Japan

Japan has the largest trade surplus in the world (US$ 88 bn in the GTAP database), and Figure 4-1 demonstrates that this is due to large net exports of manufactured goods. The world markets for transport goods (TRN). other machinery and equipment (OME) and other manufactures (OMF) are dominated by Japan, with over 20% of world exports in each of these goods. No other country or region has a trade surplus in a single good of over US$ 100bn.

Figure 4-1: Japan's Net Trade Position

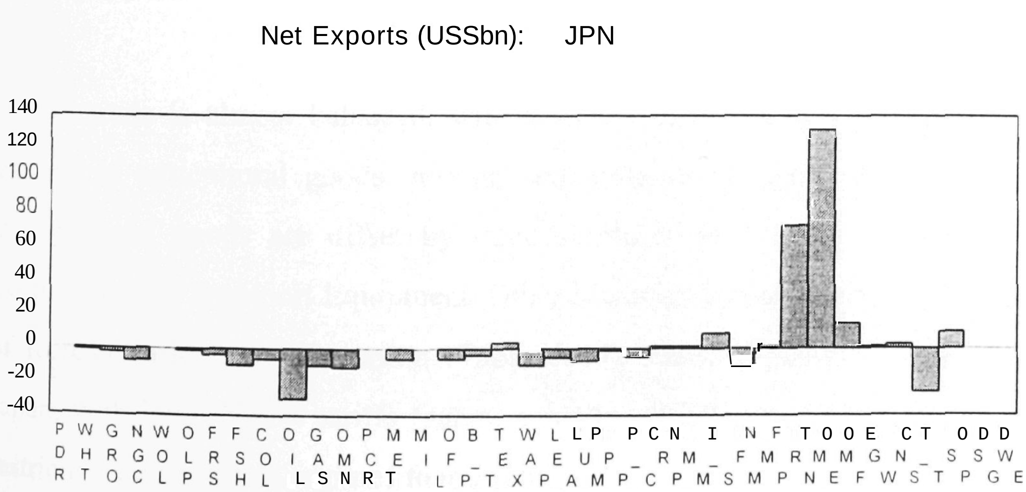


Table 4-16: The Structure of Japanese Agricultural Protection

	Output Subsidy E.xpenditure Smillion	Output Subsidy Rate %	Export Subsidy Expenditure Smillion	Export Subsidy Rate %	Import Tariff Revenue Smillion	Import Tariff Rate %
PDR	3754.95	10.10			0,52	352,53
WHT	590,87	14,80			5775,18	490,79
GRO	991.83	16.40			14051.54	463.38
NGC	21404.68	48,90			7219,89	95,80
WOL						
OLP	218,35	0,50			919,51	57,70
PCR					32,42	350,90
MET					3750,45	57,70
MIL	1330.06	7.20			2010.69	343,80
OFP					700,95	9,08
B_T					528,59	11.66
ALL	28290,73	4,60			35535,57	73.30

Table 4–16 shows that Japanese agricultural protection is characterised by very high import tariffs (in fact, for many products, by a very restrictive quota system that leads to high *ad valorem* equivalents). Output subsidies exist, and are high for Non-Grain Crops (NGC), while export subsidies are not used at all. The stringent quota system for grains (Paddy Rice PDR and Processed Rice PCR. Wheat WHT and Other Grains GRO) is a component of Japanese protection that has been severely criticised, and became a stumbling block in the Uruguay Round, as Japan sought to gain exemptions for these products.

Korea

Korean trade is almost balanced, with a small (-0.1% of GDP) trade deficit. Net imports of agricultural goods, mining and minerals (in particular. Oil) and most manufactured goods are offset by trade surpluses in Textiles, Wearing Apparel, Leather Goods, Transport Equipment. Other Manufactures and services. The structure of Korean agricultural protection (Table 4-17) shows a pattern similar to that of Japan, with large import tariffs (again, actually *ad valorem* equivalents of a highly restrictive import quota regime) for grains and Non-Grain Crops, coupled with output subsidies.

Figure 4-1: Korean Net Trade Position

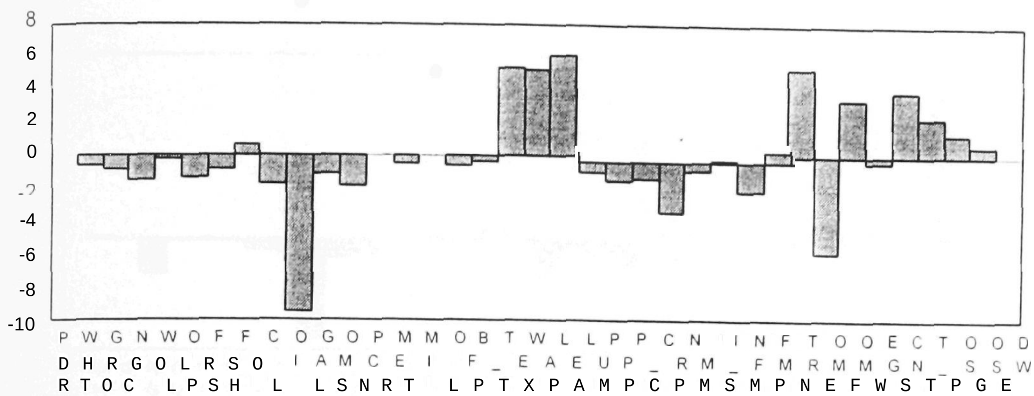


Table 4–17 The Structure of Korean Agricultural Protection

	Output Subsidy Expenditure $million	Output Subsidy Rate %	Export Subsidy Expenditure $million	Export Subsidy Rate %	Import Tariff Revenue $million	Import Tariff Rate %
PDR	4618.24	50.50			0.11	317.19
WHT	0.00	0.00			30.94	5.00
GRO	178.78	8.10			3650.45	403.40
NGC	4200.07	30.70			7408.91	382.10
WOL					20.91	10.00
OLP	989,08	14.80			677.02	40.50
PCR					22.40	316.78
MET					208.72	40.50
MIL	417.47	19.00			58.25	123.00
OFP					266.01	17.10
B_T					325.47	73.57
ALL	10502.64	11.39			12939.28	140.80

The EU

The EU's trade deficit of US$38.7bn (0,7% of GDP) is dominated by a large surplus in Trade and Transport Services (T_T) which, along with smaller surpluses in some manufactured and service sectors, partially offsets trade deficits in a range of industries - principally Oil and Other Government Services (OSG). Most agricultural and food processing sectors feature relatively balanced trade, with the exception of Non-Grain Crops, where the trade deficit is sizeable.

Figure 4-1: **Net** Trade Position of the EU

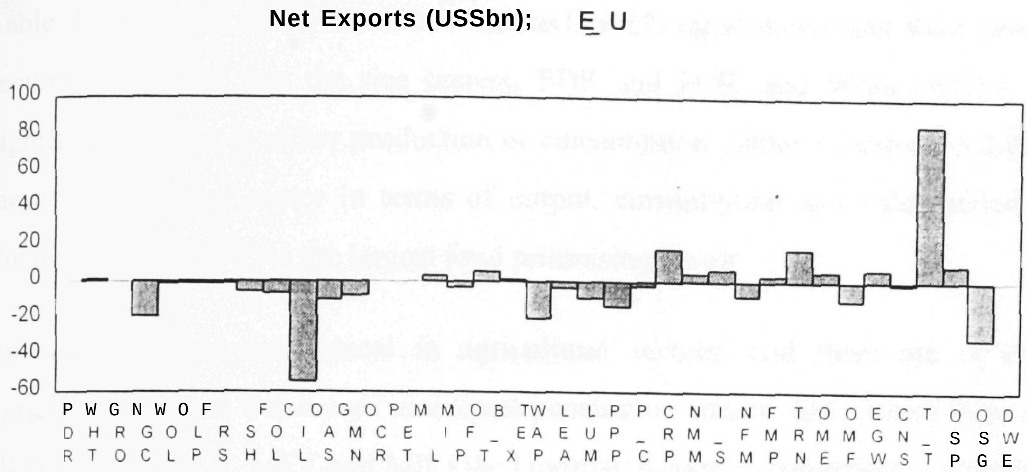


Table 4-18: The Structure of Agricultural Protection in the **EU**

	Output Subsidy Expenditure Smillion	Output Subsidy Rate %	Export Subsidy Expenditure Smillion	E.xport Subsidy Rate %	Import Tariff Revenue Smillion	Import Tariff Rate %
PDR	152.59	7.20	84.77	76.46	312.24	128.70
WHT	2286.02	6.30	2644.22	67.56	130.02	51.20
GRO	785.58	2.50	1886.80	70.66	450.73	67.60
NGC	65940.71	71.00	1333.08	23.32	13630.69	58.50
WOL	4.38	0.44	0.04	0.04	11.92	0.70
OLP	19456.64	9.20	11.10	0.70	1719.85	56.10
PCR					308.04	128.70
MET	360.39	0.20	3136.48	44.79	2300.10	56.10
MIL			4205,92	47.75	1178.83	132.90
OFP			138.09	**1.00**	2179.17	12.61
B_T					002.52	18.18
ALL	80100.20	7.34	13532.40	24.97	23690.02	36.60

EU agricultural protection makes use of all three policy instruments - output subsidies. export subsidies and import tariffs. As elsewhere, these *ad valorem* rates include many diverse intervention mechanisms. from Variable Import Levies to headage payments. Domestic output subsidies are predominantly used in Non-Grain Crops. covering a wide range of crops and intervention mechanisms. Export subsidies are predominant in grains. with significant subsidies in the Meat (MET) and Milk and

Milk Products (MIL) food processing sectors. Import tariffs are highest in Milk and Milk Products and the two rice industries (paddy rice PDR and processed rice PCR).

Table 4-18 shows sector sizes and rations for EU agricultural and food processing sectors. It is clear that the rice sectors. PDR and PCR. and Wool (WOL) are not significantly large in either production or consumption. Other Livestock (OLP) is the largest agricultural sector in terms of output, consumption and value-added. Other Food Products (OFP) is the largest food processing sector.

Low trade shares are typical in agricultural sectors, and there are several EU agricultural sectors with very low import penetration shares, and with of these sectors (WHT, GRO, OLP, MET and MIL) the Uruguay Round commitment to ensuring that import penetration ratios are at least 5% by the end of the implementation period may pose serious problems.

Table 4-19: EU **Agricultural Sector Sizes and Ratios**

	Output USSmn	Exports USSmn	Imports USSmn	Consumption (final + intermediate) USSmn	Value Added USSmn	E.xports as % of production	Import Penetration %
PDR	2119	26	243	2336	1151	1%	10%
WHT	36286	1270	256	35272	19493	3%	1%
GRO	31425	783	667	31309	16185	2%	2%
NGC	92874	4383	23300	111791	84898	5%	21%
WOL	1000	110	1703	2593	518	11%	66%
OLP	211487	1576	3066	212977	118605	1%	1%
PCR	4721	217	239	4743	1476	5%	5%
MET	179002	3866	4100	179236	38114	2%	2%
MIL	113413	4701	887	109599	43226	4%	1%
OFP	352684	13726	17286	356244	100028	4%	5%
B_T	143304	10987	4965	137282	86545	8%	4%

Taiwan

Taiwan's large trade surplus ($29bn. 13.7% of GDP) is a result of net exports in a number of manufacturing industries - the Textiles, Wearing Apparel, Leather and Lumber 'Tight manufacturing" industries as well as heavy manufacturing - Fabricated Metal Products, Other Machinery and Equipment and Other Manufactures. Service sectors are also in surplus, with the main deficit sectors being several manufacturing industries. While Taiwan's net-exporting heavy industries may look superficially like the Japanese model. Japan is not a large net exporter of the light manufactures, and unlike Taiwan, is a major net-importer of natural resources,

Taiwanese agricultural protection follows a similar patlern to Japanese protection insofar as grains are protected by stringent quotas, with high *ad valorem* tariff equivalents. Taiwan does not. howe\er have such an output subsidy regime, except for a small subsidy to Forestry (FRS),

Figure 4-1: Taiwanese Net Trade Position

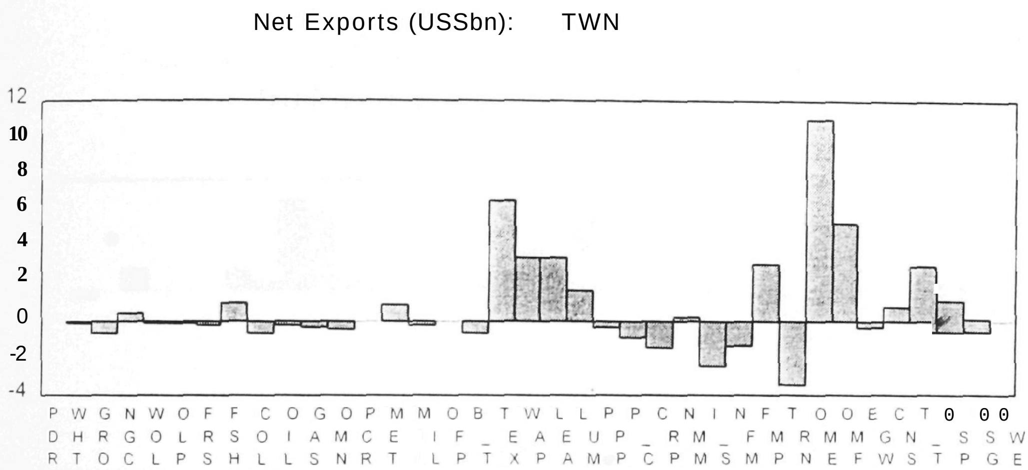


Table 4-20: The Structure of Taiwanese Agricultural Protection

	Output Subsidy E.xpenditure Smillion	Output Subsidy Rate %	Export Subsidy Expenditure $million	E.xport Subsidy Rate %	Import Tariff Revenue Smillion	Import Tariff Rate %
PDR					0.01	81.00
WHT					438.20	307.60
GRO					2214.54	325.60
NGC					912.59	72.00
WOL						
OLP					14.76	5.00
FRS	53.06	5.01				
FSH					28.30	9.17
PCR					1.31	81.00
MET					30.76	16.30
MIL					170.78	72.10
OFP					141.03	12.43
B_T					271.27	36.38
ALL	53,06	0,08			4223.74	78.06

Indonesia

Indonesia's trade structure is typical of a resource-rich developing country, in that Oil, Gas, and Lumber are the three largest net-exporting sectors, with Textiles, Wearing Apparel and Leather Goods also being net exporters. Meanwhile heavy manufacturing, and particularly Machinery and Equipment, are heavily imported.

Indonesian agricultural protection is characterised by import tariffs, particularly in Non-Grain Crops (a net export), with small levels of subsidy support in grains (Paddy Rice and Other Grains) and Non-Grain Crops.

Figure 4-1: Indonesian Net Trade Position

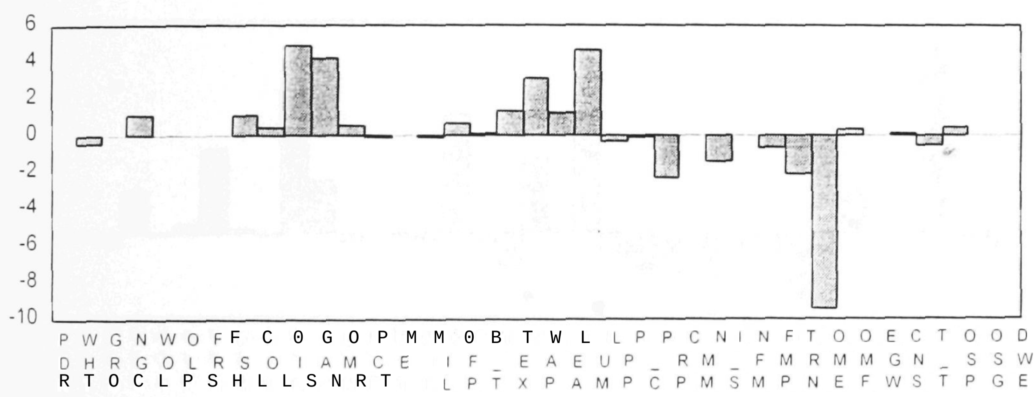


Table 4-21: The Structure of Indonesian Agricultural Protection

	Output Subsidy Expenditure Smillion	Output Subsidy Rate %	Export Subsidy Expenditure Smillion	Export Subsidy Rate %	Import Tariff Revenue Smillion	Import Tariff Rate %
PDR	324,80	4.70				
WHT						
GRO	93,65	10.60			3.35	7.82
NGC	275.64	1.90			607.60	66.50
WOL					0.05	5.00
OLP					4,84	7.60
PCR						
MET					6,84	30.00
MIL					34.74	27.70
OFP					123.71	20.00
B_T					23.46	24.05
ALL	694.09	1.29			903.62	33.54

Malaysia

Like Indonesia. Malaysia is a large net exporter of Oil. Gas. Wearing ,'\pparel and Lumber. and a net importer of most manufactures, Malaysia does however have some manufacturing exports (Other Manufactures) and large Trade and Transport Services exports. Malaysia is also a net exporter of Non-Grain Crops and Forestry. with most agricultural and food sectors either in small surplus or small deficit,

Malaysian agricultural protection is at very low levels - e\en the 13.56% tariff on Other Food Products would be considered low in many countries.

Figure 4-1: Malaysian Net Trade Position

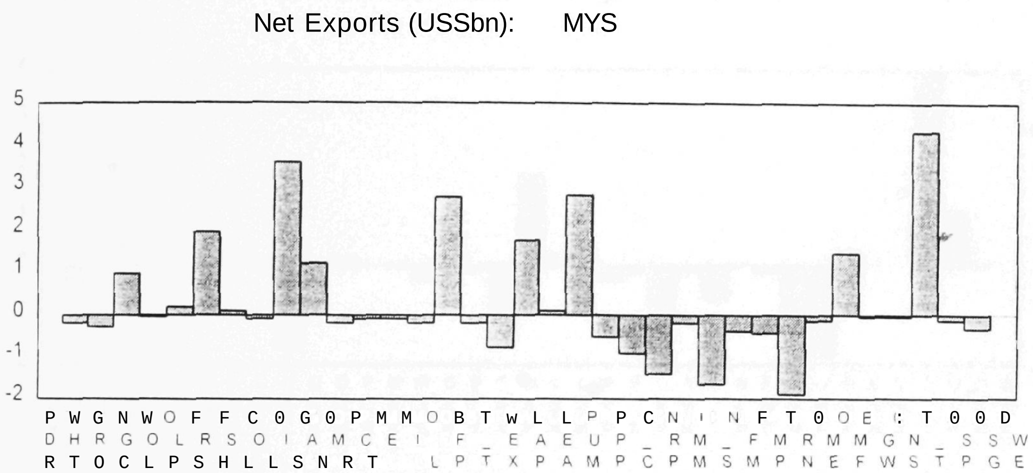


Table 4-22: The Structure of Malaysian Agricultural Protection

	Output Subsidy Expenditure $million	Output Subsidy Rate %	E,xport Subsidy Expenditure Smillion	Export Subsidy Rate %	Import Tariff Revenue Smillion	Import Tariff Rate %
PDR						
WHT					1.58	0.85
GRO					0.61	0.21
NGC					10.66	1.93
WOL					1.15	2.00
OLP					0.70	2.15
PCR					0.11	0.09
MET					1.16	1.03
MIL					3.52	1.41
OFP					117.08	13.56
B_T					2.76	0.99
ALL	0.01	0,00			147.05	5.10

The Philippines

The Philippines' main net exporting sectors are Trade and Transport Services, Other Private Services, and Wearing Apparel. As with many developing countries, most heavy manufacturing sectors are net importing sectors, and a large Oil deficit exists. Filipino agricultural protection rests on a moderate import tariff regime, with no output or export subsidies.

Figure 4-1: The Philippines' Net Trade Position

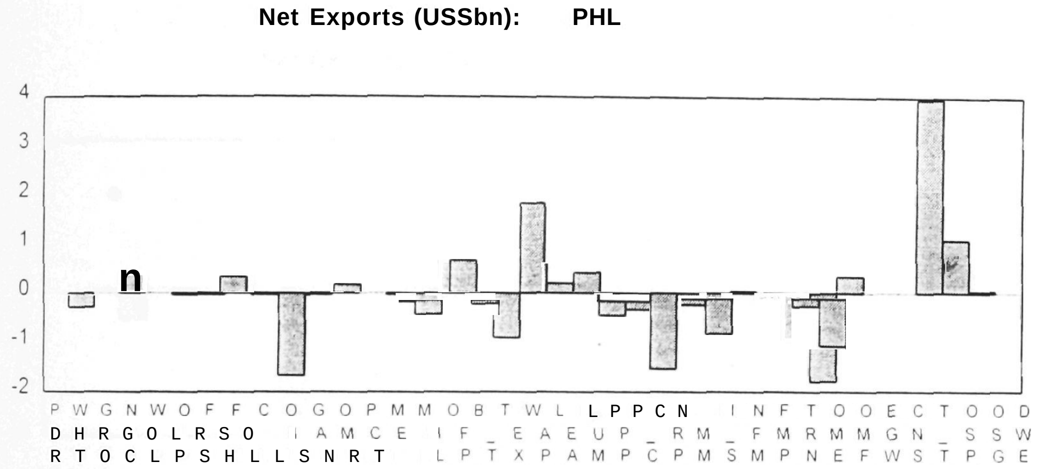


Table 4-23: The Structure of The Philippines' Agricultural Protection

	Output Subsidy Expenditure Smillion	Output Subsidy Rate %	Export Subsidy Expenditure Smillion	Export Subsidy Rate %	Import Tariff Revenue Smillion	Import Tariff Rate %
PDR					0.03	50.00
WHT					27.18	10.00
GRO					2.98	20.33
NGC					67.62	37.67
WOL					025	20.00
OLP					7.02	20.63
PCR						
MET					11.10	34.40
MIL					44.88	15.73
OFP					118.65	22.13
B_T					84.12	44.00
ALL					380.81	22,65

Singapore

Singapore's trade structure suggests it is in some ways the most de\eloped of the Asian Newly Industrialising Countries; there is no reliance on textiles and clothing, and although small trade deficits are incurred in hea\y manufacturing sectors, Singapore is a net exporter of in traded service sectors. There is also evidence that Singapore's position as an oil refiner plays a major role in its trade structure (large Oil imports, and large Petroleum and Coal exports), Singapore is a food importer - \irtually no agricultural or food production exists.

Figure 4-1: Singapore's Net Trade Position

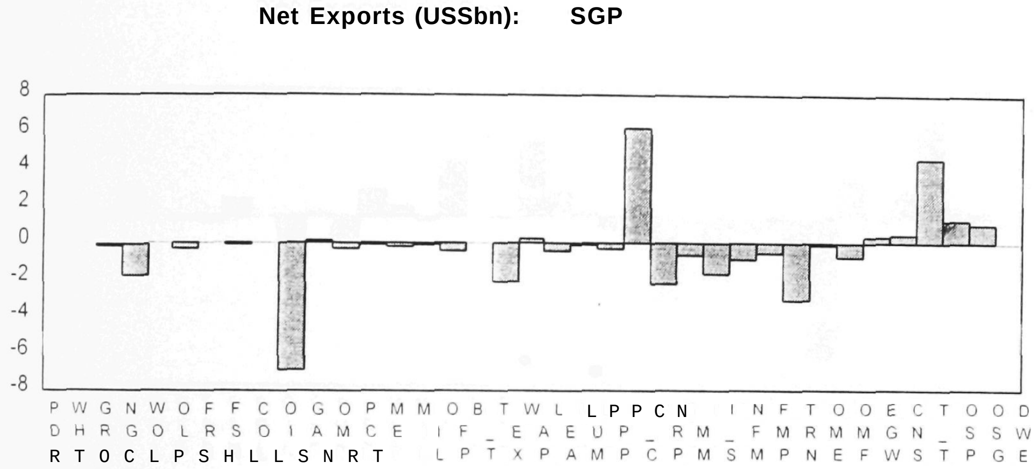


Table 4-24 The Structure of Singapore's Agricultural Protection

	Output Subsidy Expenditure Smillion	Output Subsidy Rate %	Export Subsidy Expenditure Smillion	Export Subsidy Rate %	Import Tariff Revenue Smillion	Import Tariff Rate %
PDR						
WHT						
GRO						
NGC						
WOL						
OLP						
PCR						
MET						
MIL						
OFP					2.71	0.17
B_T						
ALL					2,71	0,05

Thailand

Thailand's trade position, as shown in Figure 4-1, demonstrates a heavy reliance on manufacturing imports, with surplus sectors in services, Wearing Apparel, Leather Goods, and food products.

As Table 4-25 shows, Thailand has a moderately high level of agricultural protection, with tariffs being used as the main instrument of protection. Non-Grain Crops, Meat Products, Other Food Products and Beverages and Tobacco are all protected by tariffs around 55-60%, with smaller tariffs in other sectors. Rice production is unprotected by tariffs, with a small output subsidy in Paddy Rice production.

Figure 4-1: Thailand's Net Trade Position

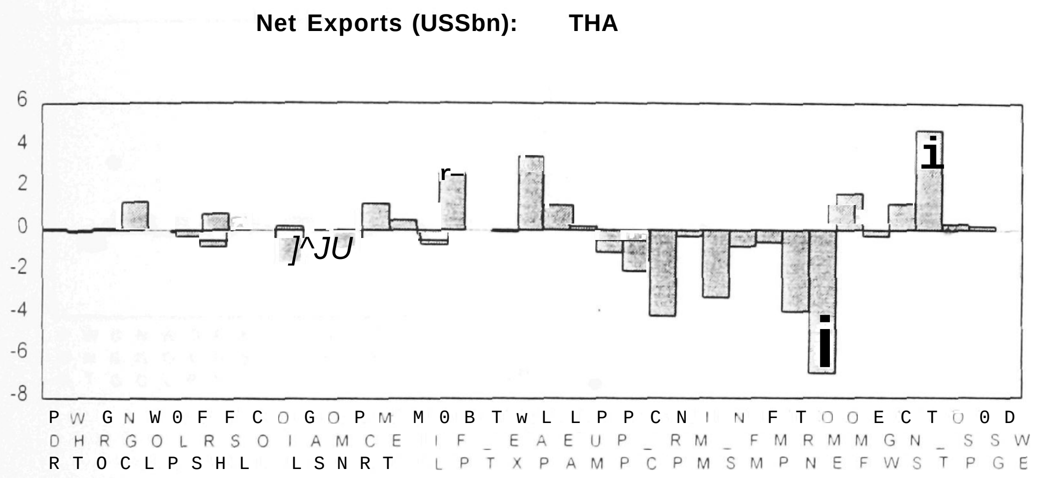


Table 4-25: The Structure of Thailand's Agricultural Protection

	Output Subsidy Expenditure Smillion	Output Subsidy Rate %	Export Subsidy Expenditure Smillion	Export Subsidy Rate %	Import Tariff Revenue Smillion	Import Tariff Rate %
PDR	82.56	2.30				
WHT						
GRO					14.58	19.40
NGC	26.94	0.40			497.06	60.40
WOL					8.52	29.99
OLP					26.33	10.81
PCR						
MET					7.51	54.14
MIL					51.34	23.11
OFP					303.67	40.71
B_T					145.68	59.53
ALL	109.50	0.26			1700.47	46.11

China

As noted earlier, China's trade surplus is very large as a consequence of exports of Wearing Apparel to Hong Kong for re-export to third markets, China has smaller trade surpluses in many other sectors, with Leather Goods and Other Manufactures being the next largest net-exporting sectors, China's net-importing sectors are mainly manufacturing sectors, with some agricultural net-imports (Wheat and Wool),

Figure 4-1: Chinese Net Trade Position

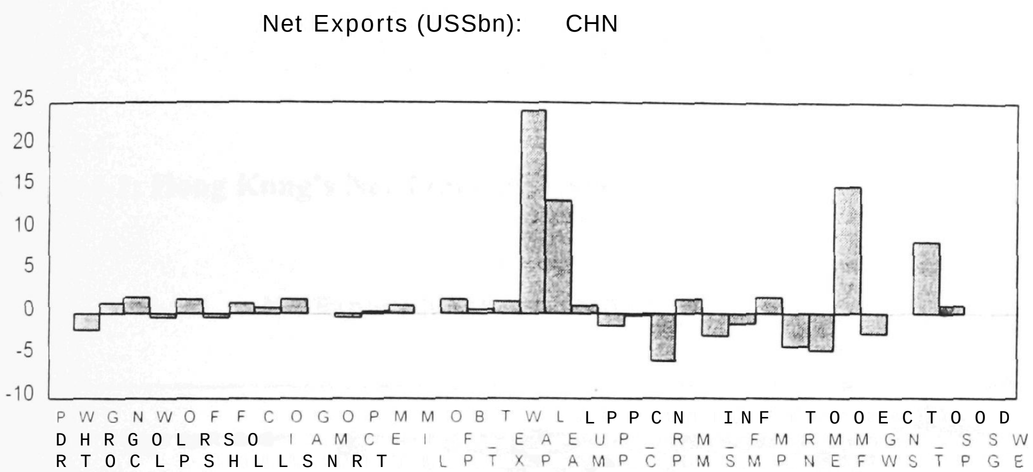


Table 4-26: The Structure of Chinese Agricultural Protection

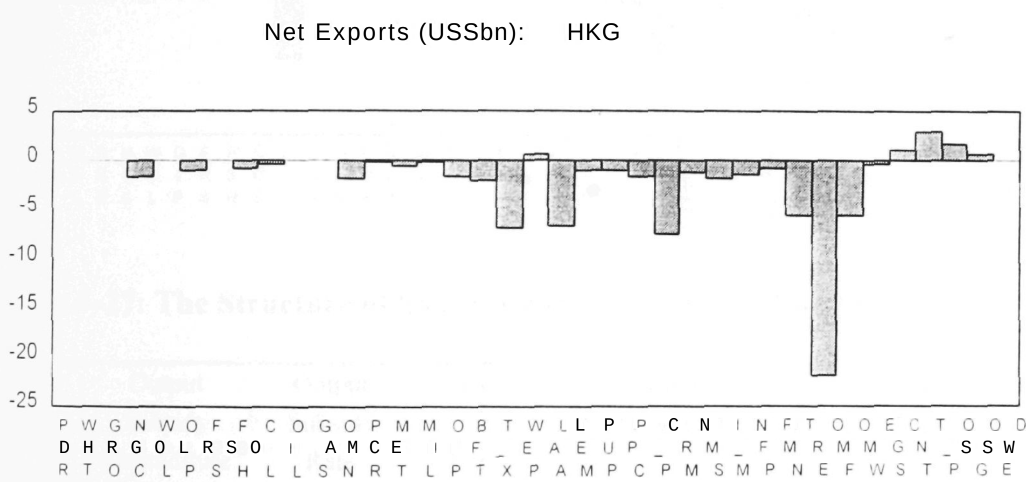
	Output Subsidy Expenditure $million	Output Subsidy Rate %	Export Subsidy Expenditure $million	Export Subsidy Rate %	Import Tariff Revenue $million	Import Tariff Rate %
PDR						
WHT						
GRO					14.87	10.10
NGC					250.40	24.21
WOL					87.63	15.00
OLP					77.30	34.00
PCR						
MET					30.30	45.37
MIL					26.60	35.52
OFP					486.00	29.41
BJ					260.60	06.75
ALL					1379.69	20.22

Table 4-26 shows that China's agricultural protection is al a moderately high level, with a particularly high tariff applied to Beverages and Tobacco. Rice is unprotected.

Hong Kong

Hong Kong's $68,2bn trade deficit is spread amongst most (with the single exception of Wearing Apparel) manufacturing sectors, with Other Machinery and Equipment showing the largest trade deficit. Service sectors show small trade surpluses, while agricultural sectors are importing sectors - very little agricultural production occurs in Hong Kong, Hong Kong has no agricultural protection.

Figure 4-1: Hong Kong's Net Trade Position



South Asia

South ,\sia. dominated by India. derives trade surpluses from fextiles. Wearing Apparel. and Leather (ioods. and is a net importer in the heavy manufacturing sectors. South Asia IS a net agricultural exporter. with Non-Grain Crops being the most significant net export.

Table 4-27 shows that South Asian agricultural protection is comparativelv low. with tariffs being used as the main protective instrument.

Figure 4-1: South-Asia's Net Trade Position

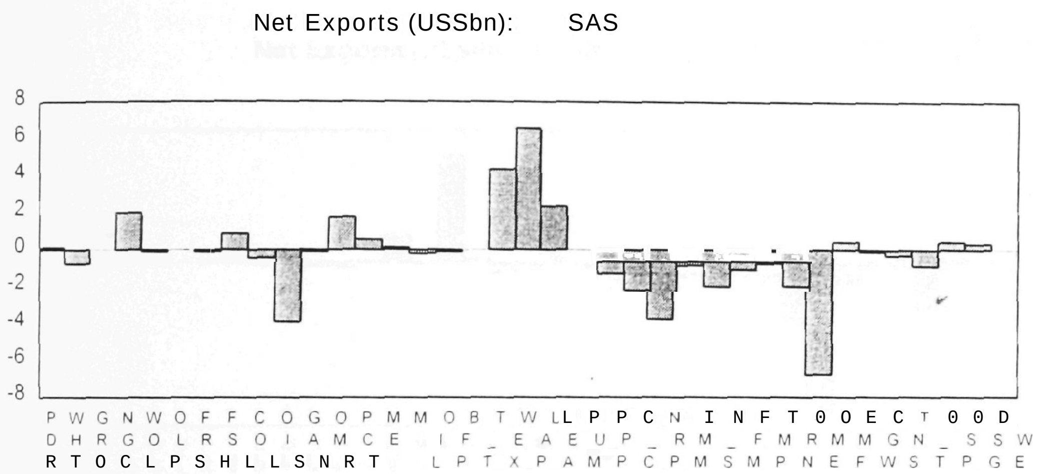


Table 4-27: The Structure of South-.Asian Agricultural Protection

	Output Subsidy Expenditure Smillion	Output Subsidy Rate %	Export Subsidy Expenditure Smillion	Export Subsidy Rate %	Import Tariff Revenue Smillion	Import Tariff Rate %
PDR	1435.32	6.20			0.00	2.08
WHT					64.18	7.08
GRO					0.66	3.80
NGC	1326.40	2.00			85.01	10.32
WOL					8.51	5.15
OLP	361.11	1.00			13.48	8.85
PCR					4.47	10.91
MET					0.53	6.57
MIL	58.89	12.70			24.48	11.95
OFP					160.97	12,32
B_T					4.53	3,05
ALL	3181.72	1.43			368.65	0.57

Argentina

Argentina's \$3bn trade deficit (1.5% or GDP) is a consequence of net imports in the manufacturing sectors, while Argentina's exports are predominantly of agricultural and food products, Argentina's agricultural protection consists of relatively low tariff rates and very low output subsidies.

Figure 4-1: Argentina's Net Trade Position

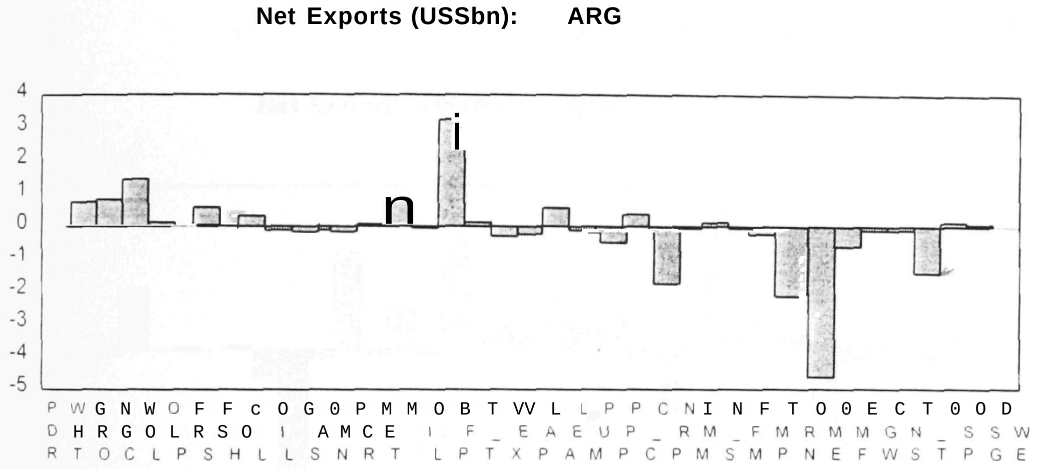


Table 4-28: The Structure of Argentinean Agricultural Protection

	Output Subsidy Expenditure Smillion	Output Subsidy Rate %	Export Subsidy Expenditure Smillion	Export Subsidy Rate %	Import Tariff Revenue Smillion	Import Tariff Rate %
PDR					0.09	12.00
WHT					1.40	20.07
GRO	0,02	0.00			0.68	14.87
NGC					41.68	17.37
WOL					0.44	21.00
OLP					10.53	17.93
PCR						
MET	0.01	0.00			16.45	12.00
MIL	0,02	0.00			29.24	21.95
OFP					50.60	16.58
B_T					25.05	20.00
ALL	0.06	0.00			184.10	17.52

Brazil

By developing country standards Brazil is very industrialised. Figure 4-1 shows that Brazil's main net-exporting sector is Ferrous Metals (I_S), with several other manufacturing sectors in net surplus. Brazil is also a net food exporter, with significant exports of Non-Grain Crops, Meat, and Other Food Products. Brazil's main net-importing sector is Oil.

Brazilian agricultural protection consists of import tariffs and output subsidies on most goods, with small export subsidies on some goods - Other Grains and Non-Grain Crops have the largest export subsidy rates.

Figure 4-1: Brazil's Net Trade Position

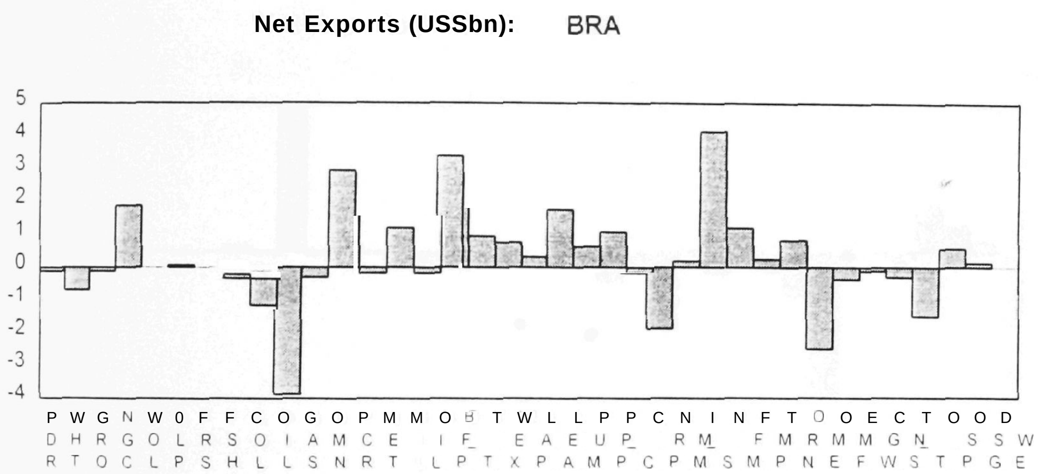


Table 4-29 The Structure of Brazilian Agricultural Protection

	Output Subsidy Expenditure Smillion	Output Subsidy Rate %	Export Subsidy Expenditure $million	Export Subsidy Rate %	Import Tariff Revenue Smillion	Import Tariff Rate %
PDR	706.00	45.60			21.83	19.66
WHT	417.52	24.00				
GRO	1791.51	28.11	0.08	3.83	31.88	22.05
NGC	96.44	0.47	68.20	2.48	166.67	21.31
WOL	2,46	0.52			0.98	25.41
OLP	1031.63	5.00			0.01	10.75
PCR					40.78	20.00
MET			12.41	0,89	57.55	20.56
MIL			0.19	1.75	75.04	36.19
OFP	132.47	0.44	30.78	0.66	604.70	48.82
B_T			0.31	0.03	20.38	30.57
ALL	4304.84	3.68	111.99	1.10	1069.53	27,80

Mexico

Mexican net-exports are dominated by Oil. Apart from Oil, only three small surpluses in services sectors prevent the Mexican trade deficit of $11.1bn (3.8% of GDP) being larger. Most manufactured goods are imported more than they are exported, with Other Machinery and Equipment having the largest deficit.

Table 4-30 shows that Mexican protection of Agriculture is relatively low, with most agricultural and food goods having applied tariffs below 20%. Small output subsidies exist, predominantly in the grains sectors.

Figure 4-1: Mexico's Net Trade Position

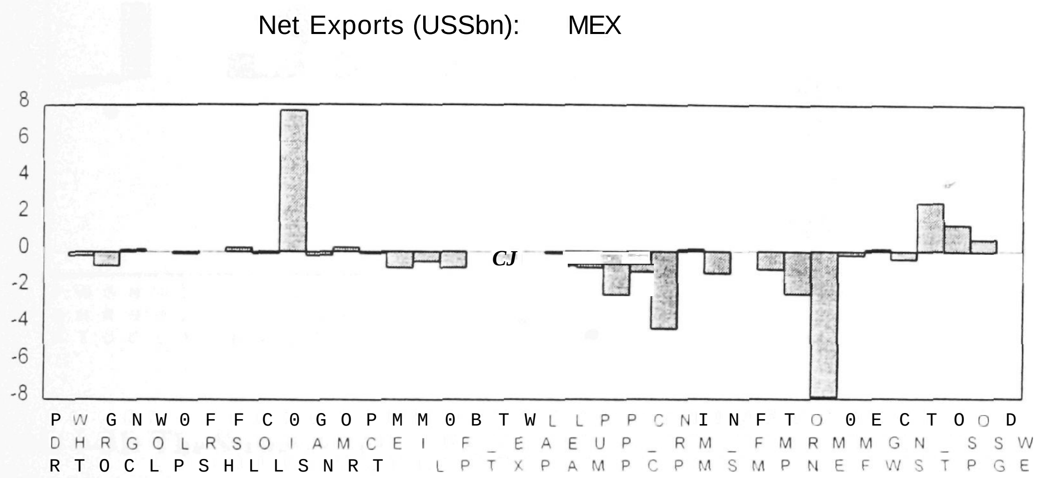


Table 4-30: The Structure of Mexican Agricultural Protection

	Output Subsidy Expenditure Smillion	Output Subsidy Rate %	Export Subsidy Expenditure Smillion	Export Subsidy Rate %	Import Tariff Revenue Smillion	Import Tariff Rate %
PDR	3,06	1.30			2.31	10.00
WHT	21.90	2.73			16.70	9.62
GRO	315.91	4.20			159.72	20.30
NGC	145.17	1.00			34.14	2.48
WOL					0.70	3.00
OLP					15.68	3.41
PCR	1.07	3.93			6.37	10.00
MET					64.01	7.19
MIL					40.25	8.25
OFP	1079.88	3.80			78.70	5.12
B_T					51.44	14.60
ALL	1567.88	1.54			486.35	7.68

Other Latin America

Other Latin American countries (Figure 4-1) are major net-importers of manufactured goods; Transport Goods and Other Machinery and Equipment together account for a trade deficit of around \$30bn. while the overall trade deficit is \$15.8bn (7.2% of GDP). Other Latin America's main exports are Non-Grain Crops and Oil. Agricultural protection consists of comparatively moderate import tariffs and very large output subsidies in grain sectors.

Figure 4-1: Other Latin America's Net Trade Position

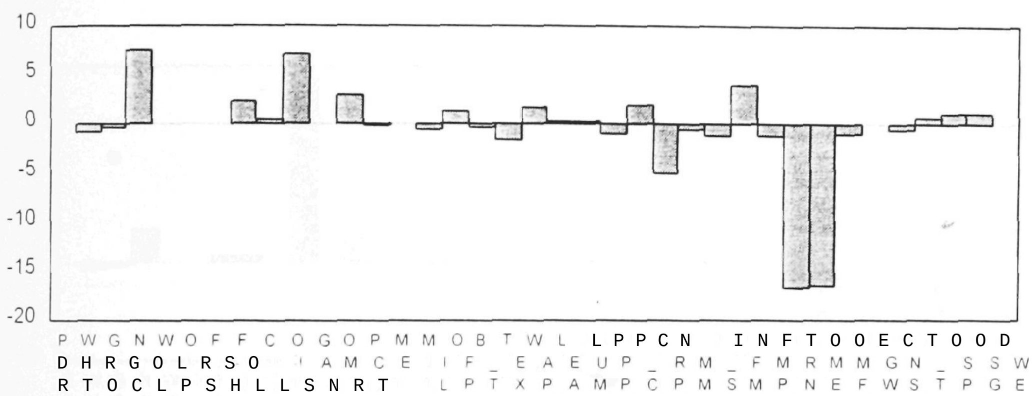


Table 4-31: The Structure of Agricultural Protection in Other Latin America

	Output Subsidy Expenditure Smillion	Output Subsidy Rate %	Export Subsidy Expenditure Smillion	Export Subsidy Rate %	Import Tariff Revenue \$million	Import Tariff Rate %
PDR	4862,58	152.05			5,79	12.05
WHT	90,73	47,76			81.06	8,88
GRO	1698.38	161.28			73.23	13.16
NGC					110.11	10.59
WOL					1.40	7,07
OLP	1 14.79	1.03			14.62	9.10
PCR					34.88	13.29
MET					81.16	13.95
MIL			0,57	0,60	109.43	14.4(1
OFP					407.21	13.62
B_T					79,97	7,09
ALL	6766,47	**6,27**	0,57	0.00	1019,65	11.78

LAM tariffs are derived from: Bolivia. Chile, Paraguay, Columbia. Ecuador, Peru.
LAM subsidies are derived from: Chile, Columbia, Jamaica, Venezuela.
[source: Hertel 1997, p.128]

Sub-Saharan Africa

Sub-Saharan Africa's trade deficit of $5.3bn (3.6% of *CAW)* occurs mainly from deficits in manufacturing sectors being only partially offset by the few net exporting sectors. Oil is the dominant net-export, with Non-Grain Crops. Other Minerals, and Non-Ferrous Metals being m smaller surpluses. It is interesting to note that Sub-Saharan Africa is a net *exporter* of agricultural and food products (a $1.4bn surplus) mainly because of a $3,4bn surplus tor Non-Grain Crops (exports of which include cash crops such as coffee and cocoa).

Figure 4-1: Sub-Saharan Africa's Net Trade Position

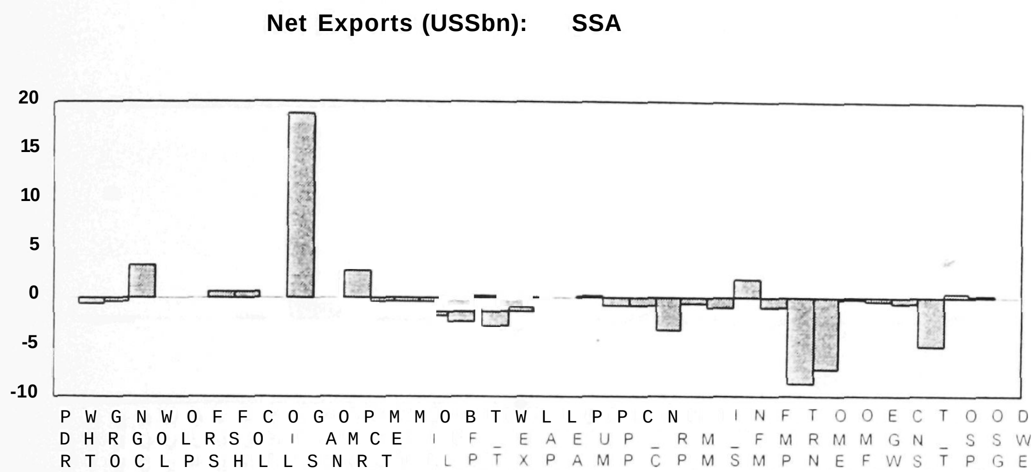


Table 4-32: The Structure of Sub-Saharan African Agricultural Protection

	Output Subsidy Expenditure $million	Output Subsidy Rate %	Export Subsidy Expenditure $million	Export Subsidy Rate %	Import Tariff Revenue $million	Import Tariff Rate %
PDR					1,07	2.80
WHT					39.38	5.53
GRO					53,60	11.17
NGC	1606.68	0,75			68.70	9.95
WOL					0,85	5.00
OLP					3.78	9.39
PCR					55.18	11.82
MET					47.60	12.83
MIL					71.64	14.11
OFP					327.14	12.59
B_T					36.82	6,42
ALL	1606.68	1,28			726.31	10.73

SSA tariffs are derived from: Kenya. Nigeria.

SSA subsidies are derived from: Kenya, Nigeria, Senegal, Zimbabwe.

The Middle East and North Africa

The Middle East and North ,Africa's trade is dominated by Oil exports, Given the size of net exports of Oil, it is surprising that the Middle Fast and North Africa has a $14.5bn overall trade deficit, 2,8"',) of GDP, The $92.5bn Oil surplus is almost completely offset by trade deficits in five sectors: Other Machinery and Equipment ($36.3bn). Transport Goods ($2(),4bn). Trade and Transport ,Services ($19.5bn). Ferrous Metals ($6.2bn) and fextiles ($6.0bn). Smaller trade delicits in other sectors

Figure 4-1: Middle East and North Africa's Net Trade Position

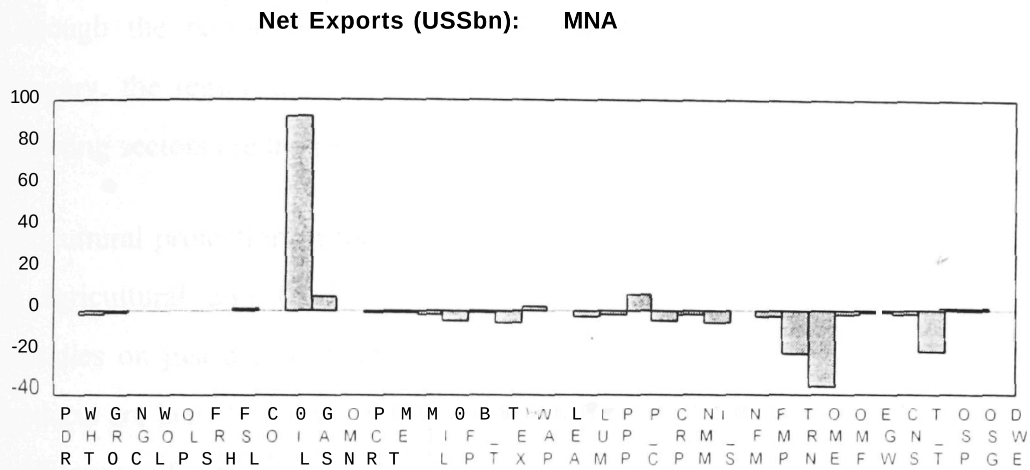


Table 4-33: Agricultural Protection in Middle East and North Africa

	Output Subsidy Expenditure Smillion	Output Subsidy Rate %	Export Subsidy Expenditure Smillion	Export Subsidy Rate %	Import Tariff Revenue Smillion	Import Tariff Rate %
PDR					2.77	2.47
WHT	439,00	145.00			119.11	5.03
GRO	414.96	42.71			157.86	11.37
NGC	6473.07	36.02			262,5(1	10.05
WOL					3.68	(1.22
OLP					05.82	9.35
PCR					100.46	12.36
MET					178.08	12.24
MIL			1.63	4,59	250.08	13.99
OFP					800.20	12.83
B_T					93.83	5.55
ALL	7328,03	5.08	1.63	0,03	2059.14	10.61

MNA tariffs are derived from: Tunisia, Algeria, Oman, Saudi Arabia.
MNA subsidies are derived from: Algeria, Egypt.

contribute to the overall trade deficit.

Agricultural tariffs in the Middle East and North Africa are fairly low, but output subsidies are very high in Wheat, with other substantial output subsidies in Other Grains and Non-Grain Crops which as they include all producer subsidies, include input subsidies on water and energy in many countries of the region.

Economies in Transition

The Economies in Transition region comprises the former Soviet Union and Eastern Europe, It has a total trade deficit of $6,6bn (0,9% of GDP) which. as Figure 4-1 shows, is largely because of a large deficit in Other Machinery and equipment. Although the region includes some net agricultural exporting countries such as Hungary. the region as a whole is a significant net agricultural importer, EIT net-exporting sectors are the primary resource industries and some manufacturing sectors.

Agricultural protection in the Economies in Transition consists of low tariff rates on all agricultural and food goods, significant output subsidies. and small export subsidies on just a few goods, Paddy Rice, Non-Grain Crops and Other Livestock Products are heavily subsidised; subsidy expenditure on each of these goods exceeds tariff revenue for all agricultural and food goods combined.

Figure 4-1: The Net Trade Position of Economies in Transition

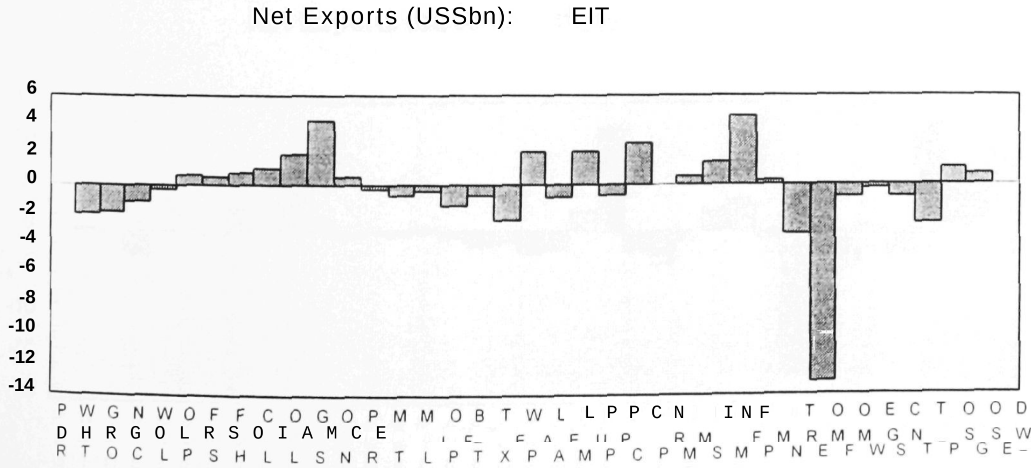


Table 4-34: The Structure of Agricultural Protection in Economies in Transition

	Output Subsidy Expenditure $million	Output Subsidy Rate %	Export Subsidy Expenditure $million	Export Subsidy Rate %	Import Tariff Reventie $million	Import Tariff Rate %
PDR	2940,06	127.05			0,06	0,26
WHT					163.18	8.09
GRO	921.85	21.26			220,44	11.30
NGC	6640.04	49.81			251.25	10.13
WOL					23.61	8.59
OLP	5386,02	28,59	0,04	0.00	20,63	9.81
PCR					16,54	8.05
MET			19.64	1.73	207.12	12.03
MIL	1080,68	13.46	38,61	9,20	114.20	14.27
OFP					381.98	12.89
B_T					84.45	7.02
ALL	16978,25	11.85	58,28	0,75	1512.85	10.74

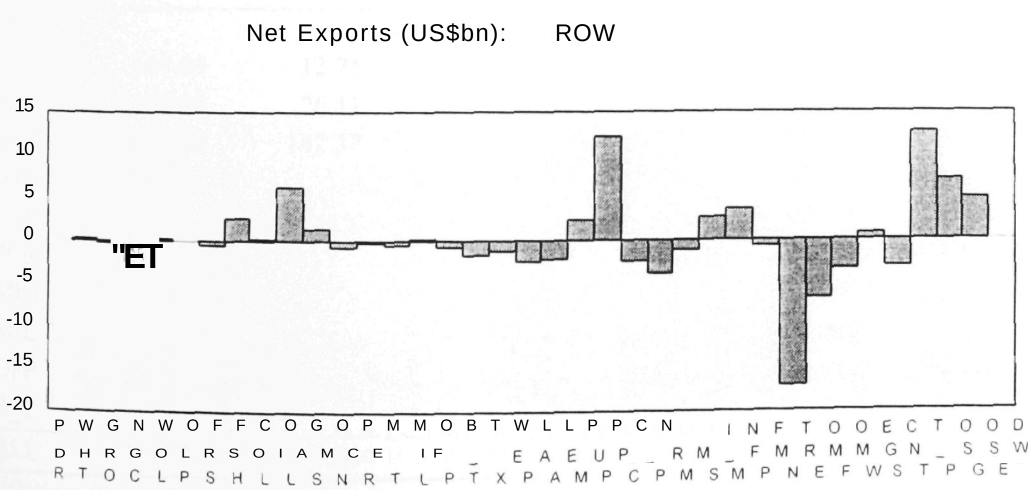
EIT tariffs are derived from: Poland, Hungary.

EIT subsidies are derived from: Hungary, Poland, Eormer Soviet Union, Yugoslavia, Czechoslovakia,

The Rest of the World

The Rest of the World is by far the most diverse regional grouping in the GTAP database. It includes Western European countries that were not part of the EC in 1992 (Sweden, Norway, Finland, Switzerland, Austria and Iceland), South Africa, Turkey. Israel, Cuba, North Korea. Mongolia, other South-East Asian countries (Vietnam, Laos. Cambodia. Mynamar). and small countries not included elsewhere (south

Figure 4-1: The Net Trade Position of the Rest of the World



Pacific nations, Cyprus, Malta, etc.). While Turkey and South Africa are large in population terms, in GDP and trade terms, the Western European countries make up most of the grouping. Harrison *el al.* (1995) rename the ROW group -EFTA".

The group has a trade surplus of $2.9bn (0.3% of income) which as Figure 4-1 shows, comes from surpluses in services sectors, resource sectors and some manufacturing sectors (Lumber and Pulp Paper Products are dependant on resource inputs). Manufacturing goods are the largest net-surplus sectors - particularly Transport Goods, Other Machinery and Equipment and Other Manufactures.

The structure of agricultural protection in this region (Table 4-35) is made up of low tariff rates. low Grain subsidy rates, and a high output subsidy rate for Non-Grain Crops. Note that the subsidy data are taken from South Africa and Turkey and extrapolated for the whole region while the tariff data are based on the Western European countries. As Western European countries are the largest in the group in GDP and trade terms, it is unfortunate that subsidy data were not available for them - the subsidies are clearly the main form of protection, but are taken from data for two of the smaller countries in the group.

Table 4-35: The Structure of Agricultural Protection in the Rest of the World

	Output Subsidy Expenditure Smillion	Output Subsidy Rate %	Export Subsidy Expenditure Smillion	Export Subsidy Rate %	Import Tariff Revenue Smillion	Import Tariff Rate %
PDR					1,26	3,35
WHT	197.09	12.71			14,21	5.17
GRO	1103.98	26.11			87,16	11.15
NGC	16630.69	142.37			498,26	9.31
WOL					8,80	7,07
OLP					95,56	9,74
PCR					35.28	11.55
MET					117.25	10,76
MIL					99.89	13,80
OFP					871,70	12,81
B_T					211.07	6.73
ALL	17931.76	9,06			2162.90	9,93

ROW tariffs are derived from: Sweden. Norway, Finland, Switzerland, Austria,
ROW subsidies are derived from: South Africa, Turkey,

4.5.5 Elasticities

Table 4-36 shows the GTAP elasticities of substitution - factor demand elasticities SIGV and the Armington elasticities SIGM, the elasticity of substitution between imports from different sources, and SIGD, the elasticity of substitution between domestic goods and imports. Data for these elasticities comes originally from the SALTER database, and much of the estimation was performed on data from the 1970s and 1980s. Where different sectors are given the same elasticity, they were originally part of the same SALTER sector.

The elasticities of substitution between factors of production are low for agricultural goods (0.56) and mining and minerals and food (1.12). Most manufacturing and services have an elasticity of 1.26. with Construction (1.40) and Trade and Transport Services (1.68) having the highest elasticides.

The Armington elasticities reflect the assumption that imports from different regions (with elasticity SIGM) should always be more substitutable between themselves than they are with domestic products. For this reason. SIGM is always set to twice the value of SIGD. The lowest Armington elasticities occur in Pulp Paper Products (PPP). Petroleum and Coal (P_C). Chemicals Rubber and Plastics (CRP) and service sectors. The highest values are in the Transport Equipment (TRN), Wearing Apparel (WAP) and Leather Goods (LEA) sectors.

Table 4-36: GTAP Elasticities

	SIGV(i)	SIGM(i)	SIGD(i)
	Elasticity of substitution between factors of production in value-added nest	Elasticity of substitution between imports from different regions of origin	Elasticity of substitution between imports and domestically produced goods
PDR	0.56	4.40	2,20
WHT	0.56	4.40	2,20
GRO	0.56	4.40	2,20
NGC	0.56	4,40	2,20
WOL	0,56	4,40	2,20
OLP	0,56	5,60	2.80
FRS	0,56	5,60	2,80
FSH	0.56	5,60	2.80
COL	1.12	5,60	2,80
OIL	1.12	5,60	2.80
GAS	1.12	5,60	2,80
OMN	1.12	5.60	2,80
PCR	1.12	4,40	2,20
MET	1.12	4,40	2,20
MIL	1.12	4,40	2,20
OFP	1.12	4,40	2,20
B_T	1.12	6,20	3,10
TEX	1.26	4,40	2,20
WAP	1.26	8,80	4,40
LEA	1.26	8,80	4,40
LUM	1.26	5,60	2,80
PPP	1.26	3,60	1,80
P_C	1.26	3,80	1.90
CRP	1.26	3.80	1,90
NMM	1.26	5.60	2,80
I_S	1.26	5,60	2,80
NFM	1.26	5,60	2,80
FMP	1.26	5,60	2,80
TRN	1.26	10.40	5.20
OME	1.26	5.60	2,80
OMF	1.26	5.60	2,80
EGW	1.26	5.60	2,80
CNS	1.40	3,80	1.90
T_T	1.68	3.80	1,90
OSP	1.26	3,80	1,90
OSG	1.26	3,80	1.90
DWE	1.26	3,80	1,90

4.6 SPECIFICS OF AGGREGATION

The thirty-seven commodities and twenty-four regions in the database allow a great deal of freedom in choosing the level of aggregation for modelling purposes. It must be made clear that aggregation is necessary: using all commodity and regions in a 37 by 24 model gives some parameter matrices for the Armington aggregation that are 37 x 24 x 24 in size - giving over 21,000 elements. Furthermore, such a model would involve 888 different goods (one commodity in each region). Since exports and various aggregates must be declared as different variables in a CGE model, such a level of disaggregation would require many thousands of variables and equations. In order to keep the time required to build and check a model, the solution time, and the time required to interpret results, to reasonable levels, a much less detailed level of aggregation must be chosen. However, as far as possible, commodities (and regions) must be aggregated together in such a way as to give as much detail as possible to the model's results. Thus the purpose for which the model is built must be borne in mind when choosing the level of aggregation.

This section details specific points that were borne in mind when choosing an aggregation for the purpose of modelling agriculture in the Uruguay Round, lists the aggregation that will be used in chapter 6, and concludes with the rationale for this particular aggregation.

4.6.1 Aggregation for modelling the Uruguay Round

A model designed to estimate the effects of the Uruguay Round of trade negotiations should have particular emphasis on the agricultural sectors. Since agriculture is a major component in the final agreement of the UR, a high level of disaggregation in the agricultural sector should be maintained. This has several implications:

- The agricultural sectors should be as detailed as possible.
- Agricultural goods users should be as detailed as possible. In particular, the food processing industries should be highly disaggregated.
- Agricultural input goods should be disaggregated.

- Those countries of particular prominence in the UR must be fully detailed (i.e. the EU. USA)

- Those countries with high levels of agricultural protection, and/or with unique protection policies or structures of protection, should be fully disaggregated. Thus the EU, USA, Japan, and Taiwan should be included on this count.

- Countries that have a high level of reliance on the agricultural sector such as Australia, New Zealand, and Canada, should be included.

- Other countries should be grouped (or detailed individually) according to both the structure of agricultural production and income category.

Several points must also be taken into account when particular emphasis is placed on EU agriculture:

- Those agricultural sectors with high levels of output and/or consumption in the EU should be included as separate commodities.

- Reference should be made to the structure of agricultural protection in the EU. The mechanisms of the Common Agricultural Policy are present in GTAP food processing sectors just as much as in agricultural sectors, so these sectors should be given the same treatment of detail as agriculture.

- The EU's main trading partners (for agricultural and food trade) should be included separately.

These points indicate that most agricultural and food processing sectors should be included as separate goods. Paddy rice, processed rice, and wool are the only agricultural and food processing sectors that have low levels of production, consumption and protection in the EU, and could be included in aggregate commodity groups.

Textiles and clothing are also important in the Uruguay Round agreement, and should be included as separate sectors. The MFA abolition also means that emphasis must be paid to the structure of textile and clothing trade, since in order to capture the level of quota restrictions properly, countries should be grouped according to whether or not they are textile and clothing exporters or importers, and whether or not they are subject to VERs. MFA exporters that have large export volumes, but low *ad valorem* equivalents of the VERs should be treated separately from exporters where the *ad valorem* equivalents of VERs are high.

The liberalisation of tariffs on manufactured goods implies that industrial commodities should be as disaggregated as possible. However, if the Agricultural Agreement is the main concern, then retaining industrial commodities as separate sectors must be of secondary importance.

4.6.2 The Modelling Aggregation

Table 4-37 and Table 4-38 define a level of aggregation that will be used in chapter 6 to model the effects of the Uruguay Round. It may be useful to explicitly define the purpose of this aggregation:

> *The Modelling Aggregation is intended to allow the most accurate portrayal of the Uruguay Round and its effects on EU agriculture as is possible within constraints imposed on the overall aggregation size.*

The aggregation encompasses seventeen commodities and thirteen regions. This is a large model aggregation, and is larger than many of the models used in studies discussed in chapter 3.

Five agricultural commodities are defined in Table 4-37. from the total possible six commodities in the GTAP database; wool is included with 'other livestock products'. Four food commodities are defined from the total five GTAP commodities - the new group "other agricultural products" includes beverages and tobacco, other food, and leather products. All other primary commodities are included as a single sector. Textiles and clothing are included separately, and four other manufacturing commodities are aggregated in a way that is intended to keep input goods (the utilities, chemicals and machinery) distinct. Services are included as a single sector.

The regional aggregation defines five OECD regions, five middle-income LDC regions, and three low-income LDC regions.

Table 4-37: Commodities in the Modelling Aggregation

Code	Aggregated Commodities	Disaggregated Commodities included in Group
Agricultural		
PDR	Rice	pdr
WHT	Wheat	wht
GRO	Grains	gro
NGC	Non-grain crops	ngc
LIVE	Livestock	olp, wol
Other Primary		
OPV	Other Primary Industries	for, fsh, col, oil. gas, omn
Food **Products**		
PCR	Processed rice	pcr
MEAT	Meat products	met
MILK	Milk products	mil
GAP	Other agricultural products	ofp, b_t, lea
Textiles **and Clothing**		
TEX	Textiles	tex
WAP	Wearing Apparel	wap
Manufacturing		
EGY	Energy	p_c. egw
CRP	Chemicals rubbers and plastics	crp
OME	Machinery and equipment	ome
OMF	Other manufacturing	omf fmp, nmm. i_s, nfm, trn. lum. ppp
Services		
SRV	Services	t_t, cns. osp. osg, dwe

Table 4-38: Regions in the Modelling Aggregation

Code	Aggregated Region	Disaggregate Regions included in Croup
OECD Regions		
ANZ	Australia and New Zealand	AUS,NZL
CAN	Canada	CAN
USA	United States of America	USA
JPN	Japan	JPN
EU	European Union	E_U
Middle-Income LDCs		
SKT	Taiwan and South Korea	KOR,TWN
SHK	Hong Kong and Singapore	HKG,SGP
EIT	Economies in Transition	EIT
BRA	Brazil	BRA
OMI	Other Middle-income	ARG,MEX,LAM,MYS,PHL.THA.MNA,ROW
Low-income LDCs		
SSA	Sub Saharan Africa	SSA
CHN	China	CHN
OLI	Other Low Income	SAS,IDN

4.6.3 Rationale for the Modelling Aggregation

This section discusses the precise reasons for each part of the modelling aggregation. It should of course be borne in mind that choosing an aggregation is largely a matter of trade-offs. For every commodity or region that is added to the model, the advantages of the inclusion of that commodity or region must be weighed against the costs, either in terms of the extra solution time (and sometimes the difficulty in reaching a solution) or in terms of the commodity or region that must be removed to keep the model size unchanged.

Agricultural Commodities

With the exception of wool, all GTAP agricultural commodities are included, and wool is excluded because of its low level of production and consumption not only in the EU but also globally. Australia (accounting for 68% of world wool exports) is the only country that is likely to be effected by the exclusion of wool from the model. The only country that applies high levels of protection to wool is the US.A, where a large production subsidy exists, but even there wool output is low compared to other sectors (see Table 4–15 for details). Wool is therefore included in the livestock sector.[1] Paddy rice is included mainly because it is extremely important in East Asia, and much of the general equilibrium effects of the Uruguay Round may come from the interaction between textiles and clothing and agriculture in Asia.

Primary Products

The inclusion of other primary products in a single commodity is not ideal, but is justified because these sectors are unlikely to play a large part in the outcome of the Uruguay Round. Francois *et al.* (1994) include a separate simulation for the effects of tariff reductions on non-agricultural primary products, and find that the effects are negligible.

[1] It could be argued that because wool and sheep meat are joint products, it should be included with the livestock sector.

Food ***Products***

Meat and milk products are included separately, and this is considered to be essential for modelling EU agriculture. Apart from the inclusion of processed rice. for which the same comments apply as for paddy rice, the only other food product is "other agricultural products", which is a heterogeneous group containing other food, beverages and tobacco. and leather products. While 'leather products' is clearly not a food product. and is not subject to protection under the CAP, it is a relatively small sector (value added in the EU for this group is composed of 65% other food products, 26% beverages and tobacco, and *9%* leather products) and predominantly uses intermediate inputs from the livestock sector. Thus "other agricultural products" is best thought of as "other processed products that primarily use agricultural products".

Textiles and Clothing, Manufacturing and Services

There is a large degree of aggregation in the manufacturing and service sectors, but this is acceptable in an agriculture-focused model. Textiles and clothing are included as separate cominodities, and those manufactured products that are mainly used as intermediate products or as capital are defined separately. The definition of the energy commodity uses a manufactured good (petroleum and coal) and a service (electricity, water and gas): ideally these would be defined separately, but in the context of the trade-offs associated with choosing aggregations, the inclusion of these commodities together is preferable to defining either as part of one of the larger aggregates.

OECD Regions

Each GTAP OECD region is included separately, with the exception of Australia and New Zealand which, mainly because of the size of New Zealand, are aggregated together. It should also be noted that the GTAP "Rest of the World" region includes non-EU Western Europe. Whether this region should be treated as an OECD region or not is debatable; Hertel *et al.* (1995) treat it as a developing country, Francois *et al.* (1995) use additional data to split the region into EFTA countries and a developing country ROW group, while Harrison *et al.* (1995) simply rename the region EFTA and treat it as a developed region. Here it is treated as a middle-income developing region.

Middle-Income LDCs

The four East Asian newly industrialised countries are treated differently by different modellers. The importance of the MFA to some of these countries is paramount, but the aggregation here is primarily defined by agricultural considerations; Hong Kong and Singapore are both free-trade food importers with little or no agricultural production, while Taiwan and Korea are high-protection countries with large agricultural sectors. Evidently combining these countries in any other way would mix the opposite extremes of agricultural protectionism and entirely different agricultural structures. Separating all four countries is deemed unnecessary because the pairings do lead to a matching of similarities.

The other middle-income LDCs involve some inevitable aggregation, in part because the GTAP database is (because of its Australian roots) biased towards a high level of detail in South East Asia - there are many other African and South Asian LDCs that are larger than Malaysia and the Philippines, for example. It is considered necessary to identify Brazil and "economies in transition" as separate regions because of their high levels of agricultural protection, and in that latter case because of its proximity to and large trade with the EU.

Low-Income LDCs

It is considered to be necessary to provide separate treatment for low income LDCs, primarily because of the possibility of a negative impact on these regions from the Uruguay Round, and particularly as a result of the reform of EU export subsidies. China is included separately because (a) it is not a WTO member, and therefore does not need to make tariff reductions unless it joins the WTO and (b) it is so large that it would dominate the results of any aggregate region that included it. Sub-Saharan Africa does not have to make reforms as a result of the Uruguay Round because of least-developed status. The inclusion of South Asia and Indonesia in a single group is an unfortunate result of the need to keep the size of the aggregation from being too large, but the extent of liberalisation in these regions as a result of the Uruguay Round is likely to be small.

4.7 MODIFYING THE GTAP DATABASE FOR USE IN GAMS

The standard means of aggregating the GTAP database that is supplied with the GTAP database software consists of inputting the desired aggregate commodity and regional names and the mappings from disaggregate to aggregate sets into a text file in a particular format.

The largest single problem with using the GTAP software for the aggregation that is proposed here is that GTAP have limited the size of the aggregation that their marketed software can achieve to a maximum of ten aggregate regions and ten aggregate commodities. To perform a larger aggregation, such as the thirteen-region, seventeen-commodity aggregation in mind, some other way of aggregation must be performed. Two main alternatives exist: using a GEMPACK source-code licence, and using Rutherford's routines for transferring GTAP into GAMS.

GEMPACK software comes with two types of licence, an executable licence and a source code licence. The executable licence allows the running of the main programs in the GEMPACK software suite[2]. The executable licence has two main limitations: TABLO.EXE can only write GEMSIM input files, and GEMSIM is limited to using 8 Mb of computer memory - effectively limiting all simulations and data manipulation to the ten-region, ten-commodity size of the GTAP limits. A source-code licence enables TABLO to write FORTRAN files that, with a FORTRAN compiler, will produce executable programs that can then run a model of any size. Thus a source-code licence will enable the use of GEMPACK for any size of model (limited only by computer memory). GEMPACK source-code licences, however, cost several thousands of pounds, while the executable licence costs just a few hundred pounds.

[2] The GEMPACK suite consists of eleven programs, the main ones being:

- TABLO.EXE checks and compiles models
- GEMSIM.EXE performs simulations from the files outputted by TABLO
- GEMPIE,EXE transfers GEMSIM solution files into text print files
- SEEHAR.EXE prints GEMPACK header array files (the binary form that GEMPACK data is stored in) to text files.

Routines developed by Thomas Rutherford of the University of Colorado enable the use of SEEHAR.EXE to produce a GAMS file. These routines take advantage of new features of the latest versions of GEMPACK (version 5.2) and the GTAP database (version 3). GEMPACK 5.2 includes a feature in SEEHAR to print GAMS files, so that a GEMPACK data file can be easily converted to GAMS. Unfortunately, although an executable-licence version of GEMPACK 5.2 was used here, the version of GTAP used is version 2. The main reason not to upgrade to GTAP version 3 is that there were no new data added to the database between versions 2 and 3 (there is a small increase in the number of regions covered in the database, but the base year for the data and the number of commodities remains the same). Upgrading to version 3 of the database would, however, allowed the use of SEEHAR to re-write the data.

The reason that SEEHAR cannot be used with GTAP version 2 is that GTAP 2 stores the disaggregate data in parameters formerly used in the Australian SALTER modelling framework. and these parameters are much larger than the GTAP parameters (the conversion between SALTER parameters and GTAP parameters is normally done by the GTAP aggregation software for models not exceeding ten-regions and ten-commodities). GTAP 2 thus exceeds memory limits in this exercise where GTAP 3, which stores the data in GTAP parameters, does not.

4.7.1 GTAP Global Data in SALTER notation:-

As noted above, the GTAP data for version 2 of the database is held in SALTER notation. The form that this takes is as follows (note that ii is used as an alias for set i):-

DI01(i,ii,r)	Intermediate usage of domestic product, by commodity, industry and region.
DI02(i,ii,r,s)	Intermediate usage of imports, by commodity, industry, destination region and source region.
DI03(i,r)	Investment usage of domestic product, by commodity and region.
DI04(i,r,s)	Investment usage of imports, by commodity, destination region and source region.
DI05(i,r)	Household consumpfion of domestic product, by commodity and region.
DI06(i,r,s)	Private household consumpfion of imports, by commodity. destination region and source region.

DI07(i,r)	Government consumption of domestic product, by coinmodity and region.
DI08(i,r,s)	Government consumption of imports, by commodity, destination region and source region.
DI12(i,r)	Non-commodity indirect taxes, by industry and region.
DI13(i,r)	Labour usage, by industry and region.
DI14(i,r)	Capital usage, by industry and region.
DI15(i,r)	Land usage, by industry and region.
DI16(i,ii,r)	Tax on intermediate usage of domestic product, by commodity, industry and region.
DI17(i,ii,r)	Tax on intermediate usage of imports, by commodity, industry and importing region.
DI18(i,r)	Tax on private household consumption of domestic product, by commodity and region.
DI19(i,r)	Tax on private household consumpfion of imports, by commodity and importing region.
DI20(i,r)	Tax on investment usage of domestic product, by commodity and region.
DI21(i,r)	Tax on investment usage of imports, by commodity and importing region.
DI22(i,r)	Tax on government consumption of domestic product, by commodity and region.
DI23(**i**,r)	Tax on government consumption of imports, by commodity and importing region.
DI24(i,r,s)	Export tax, by commodity, source region and destination region.
DI27(i,r,s)	Import duty, by commodity, destination region and source region.
DI31(i,r,s)	International trade and transport margin, by commodity, destination region and source region[3]
DI32(i,r)	Margin exports of trade and transport services.
DI41(r)	Capital stock, by region.
DI42(r)	Depreciation, by region.

In all cases, the commodities and regions in the descriptions above are in the order that they occur in the sets over which the parameter is defined. Taxes are all given in value of tax payments form, so that the tax rate is found by dividing the tax by the relevant parameter.

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3 In the e-mail from Rob McDougal that describes these SALTER form of parameters, this was "by commodity, source and destination". Tests on the data proved that the source and destination were given the wrong way around.

There are several main points of difference between this form of parameters and the standard GTAP form:-

GTAP uses values at market and agents' prices, while the SALTER parameters use values (at market prices) and tax payments. The value at agents' prices is found by adding the tax payment to the value at market prices if the tax is paid for the consumption of use of a good, and (in the case of the output tax (DI12) and export tax (D124)) by subtracting the tax payment from the value at market prices where the tax is paid by the agent selling the good.

The SALTER data have no parameters defined over the set j, which is the combination of the i set and capital goods ("cgds"). Wherever a GTAP parameter is defined over j, it can be found from SALTER parameters for i and investment (for "cgds") separately. For example, VDFM(i,j,r) can be found by the following two assignments:

VDFM(i.ii,r) = D101(i,ii.r)
VDFM(i,"cgds",r) = DI05(i,r)

The SALTER data do not explicitly define any trade volume, but these can be found by working through the import demands. Since there are four forms of demand in the SALTER framework - intermediate demands, investment usage, private household demands and government demands - the value of imports at domestic market prices is:-

VIMS(i,r,s) = intermediate demand from DI02
+ investment demand from DI04
+ private demand from DI06
+ government demand from DI08

The other GTAP trade parameters can be calculated from VIMS:

VIWS(i,r,s) = VIMS(i,r,s) - import duty from DI27
VXWD(i,r,s) = VIWS(i,r,s) - transport margin from DI31
VXMD(i.r,s) = VXWD(i.r,s) - export duty from DI24

The SALTER data do not define regional savings. These are calculated as the residual between regional income and regional expenditure on private and government consumption.

Regional income = net factor income (D113 + D114 + D115 - D142)

+ tax income (DI12 + D116 + DI17 + DI18 + D1I9 + DI20 + DI21 + D122 + DI23 + D124 + DI27)

Regional Expenditure = private expenditure at agents' prices (DI05 + D106 + D118 + D119)

+ government expenditure at agents' prices (D107 + D108 + DI22 + DI23)

Care must be taken later when performing this calculation to ensure, in the case of trade taxes especially, that the region receiving the tax revenue is credited correctly.

When calculating savings as income minus expenditure, taxes on private and government consumption cancel out, so that savings equals:-

Savings= D113 + DI14 + D115 - DI42 + DI12 + D116 + D117 + D120 + DI21 + D124 + DI27

- (DI05 + DI06 + D107 + DI08)

The SALTER parameters in some cases include more data than are necessary for use in GTAP. The largest parameter in this database is DI02, which is defined over(i,ii,r,s). With i and ii comprising 37 commodities and r and s 24 regions in the disaggregate database, the size of this parameter is 37x37x24x24 = 788,544 (which, since GEMPACK used 4 bytes of computer memory to store each point of data, uses just over 3 Mb of memory). The size of this parameter is the main source of problem when using GEMPACK software - it is simply too large. DI02 is needed to calculate VIMS (imports at market prices) and VIFM (intermediate usage of imports), and is aggregated differently for each.

4.7.2 Transferring SALTER notation into GTAP notation

The following assignments describe the complete system of formulas to transfer GTAP data from SALTER notation to GTAP notation:

Values at Market Prices:

VFM("Labour",j,r) = DI13(j,r)

VFM("Capital",j,r) = DI14(j,r)

VFM("Land",j,r) = DI15(j,r)

VDFM(i,j,r) = DI01(i,j,r)

VDFM(i,"cgds",r) = DI03(i,r)

VIFM(i,j.r) = SUM(s. D102(i,j.r,s))

VIFM(i."cgds".r)= D104(i.r)

VIPM(i.r) = SUM(s, DI06(i,r,s))

VDGM(i,r) =DI07(i,r)

VIGM(i,r) = SUM(s, DI08(i,r,s))

VST(i.r) = DI32(i,r)

VIMS(i,r,s) = SUM(j, DI02(i,j,s,r)) + DI04(i,s,r) + DI06(i,s,r) + DI08(i.s,r)

Values at agents' prices (using any market price values calculated above):

EVOA(f,r) = SUM(j, VFM(f.j,r))

EVFA(f,j,r) = VFM(f,j.r)

VDFA(i,j,r) = VDFM(i,j,r) + DI16(i,j,r)

VDFA(i,"cgds",r) = VDFM(i,"cgds",r) + DI20(i,r)

VIFA(i.j.r) = VIFM(i,j,r) + DI16(i,j,r)

VIFA(i."cgds",r) = VIFM(i,"cgds",r) + DI21(i,r)

VDPA(i,r) =VDPM(i,r) + DI18(i.r)

VIPA(i,r) = VIPM(i.r) + DI19(i,r)

VDGA(i.r) = VDGM(i,r) + D122(i,r)

VIGA(i.r) = VIGM(i,r) + D123(i.r)

VDEP(r) = DI42(r)

VKB(r) =D141(r)

Trade **Flows (calculated from VIWS(i,r,s) given above):**

VIWS(i,r,s) = VIMS(i.r.s) - DI27(i,s.r)

VXWD(i,r,s) = VIWS(i,r,s) - D131(i,s.r)

VXMD(i,r,s) = VXWD(i,r,s) - DI24(i,r,s)

Savings **(calculated as the residual of regional income - expenditure):**

SAVE(r) = SUM(i, DI13(i.r) + DI14(i,r) + DI15(i,r)) - DI42(r)
+ SUM(i, DI12(i,r) + DI20(i,r) + DI21(i,r))
+ SUM((i,j), DI16(i,j,r) + DI17(i,j,r))
+ SUM(i,s), DI24(i,r,s) + DI27(i,r.s))
- SUM(i, DI05(i.r) + DI06(i,r))
- SUM((i,s), DI06(i,r,s) + DI08(i,r,s))

4.7.3 GEMPACK Header Array Files

GEMPACK uses its own standard form for storing data, called Header Array Files with the name extension of "har". The four files used to store the GTAP database are:

Global.har:	all the SALTER notation parameters described above.
Price94.har:	price elasticities for private consumption
lnc94.har:	income elasticities for private consumption
Subst.har:	elasticities of substitution.

The last three files will be detailed below, but the form in which they store data is identical to that for Global.har and any other header array file.

The format of header array files described here was found by extensive testing of header array files using a hex editor.[4] Where necessary, some values are given in hexadecimal notation, prefixed by the characters &h. So, for example, the number 11 is equal to &hB. Header array files, like any computer file, are a long series of bytes (numbers in the range 0 - 255. or &h0 to &hFF), the interpretation of which differs according to how they are used. In some cases the bytes are interpreted directly as numbers, in other cases, pairs of bytes are interpreted as integers (numbers in the range -32768 to +32767). A sequence of four bytes can be interpreted as a long integer (numbers in the range -2,147,483,648 to 2,147,483,647) or as single precision real numbers (real numbers in the range 3.4E-38 to 3.4E+38). Alternatively, bytes can be interpreted as ASCII codes representing characters.

A header array file consists of a number of header arrays, each of which contains a header containing information about the array, and the array itself, which can be either a series of text strings, or a series of bytes represenfing a table of single precision real numbers. The header arrays are stored one after another: no information at the start of the file describes how many header arrays are on the file - the last header is read when the end of the file is reached.

A header array is always preceded by the four bytes &hl3,&hOO,&hOO,&hOO (as a long integer, this is interpreted as the number 19. The short name of the header

[4] The hex editor used is Hex Workshop, a shareware program. It allows the viewing of computer files directly as a series of numbers.

follows, which is always four bytes (or letters) long. Then follows four bytes that identify the array as either a text array (the bytes &h20,&h73,&h01,&h00, which can be interpreted as the long integer 95008), or as a real array (if the bytes are &h20.&hC3,&h01.&h00, or 115488 as a long integer). These four bytes are sometimes followed by a null byte (&h00), but in some cases are not - this seems to be in order to keep the following byte on an even-numbered position in the file, the reason for which is unclear. This is followed by 80 bytes giving an 80-character long name for the header array.

The naming information is followed by four bytes interpreted as a long integer giving the number of dimensions that the array is defined over. followed by a long integer for each dimension giving the size of that dimension. GEMPACK allows parameters to have up to seven dimensions, and although the largest array in the GTAP database has four dimensions (for DI02), the sizing information always gives real arrays that have seven dimensions. An array defined over TRAD_COMM (size 37 = &h25) and REG (size 24 = &h18) therefore has the eight long numbers: &h7.&h25,&hl8,&hl,&hl,&hl,&hl,&hl. Real arrays are then followed by 134 bytes, text arrays are followed by 22 bytes (in both cases, the meaning of these bytes is unidentified). The array follows after that. An example follows, taken from Global.har for the header array DI01. Here all bytes are given in their hexadecimal form, followed by a description. Note that text strings often contain the space character (=&h20) as padding.

Example Header Array

13000000	**Long integer = 17**
44493031	**Short name = "D101"**
20C3010000	**Identifies real array (+ a null** byte)
20202020524C46554C4C2020202020202020202020202020202020202020202020202020202020202020202 020202020202020202020202020202020202020202020202020202020202020202020202020202020	
	80 character long name " RLFULL "
07000000	**Long integer = 7 (number of dimensions)**
25000000	**Long integer = 37 (size of first dimension)**
25000000	**Long integer = 37 (size of second dimension)**
180000000	**Long integer = 24 (size of third dimension)**
10000000	**Long integer = 1 (size of fourth dimension)**
10000000	**Long integer = 1 (size of fifth dimension)**
10000000	**Long integer = 1 (size of sixth dimension)**
10000000	**Long integer = 1 (size of seventh dimension)**
1D1A30000002020200B000000070000002500000025000000180000000100000001000000010000 0001000000B003010000202020200A00000001000000250000000100000025000000010000000005000 00001000000010000000100000001000000010000000100000001000000010000000111F3AB010020 2020200900000003DBA640DB	
	135 unidentified bytes.

Text arrays in the GTAP database header array files include text for creation information, and descriptions of the last changes made to files. As such, they are of no interest when compiling the database, except that the total length of the array needs to be calculated in order to find the starting point for the next header array in the file. The exact format of text arrays will not be examined here. Each character in a text array is one byte long, so that an array defined as having two dimensions, the first dimension as 3, and the second dimension as 46, will be three strings of 46 characters. The size of the array is then 3 x 46 = 138 bytes.

Real arrays are complicated by the way that GEMPACK saves data. For arrays with more than two dimensions (i.e. arrays with more than two dimensions of size greater than one), each two-dimensional table is held on the file separately. If, for example, an array is defined over i,r,s, then the array consists of 24 tables, each with 37x24 elements (first dimension size times second dimension size). For the main part, these tables are held on the file one after another, but approximately every five to nine tables 84 bytes are inserted into the file, with no apparent use. Tests showed that the first four bytes of this spare block of bytes can always be interpreted as a real number below 1E-30 (10^{-30}), while no actual data in the database are ever this low. This is the only way of identifying the spare blocks - no indication of their presence or locafion is given in the header.

Summary of information included in header arrays containing real data:

Length	Type	Description
4 bytes	Long Integer	17
4 bytes	Characters	short name
4 bytes	Long Integer	identifies real array if = 115488 or text array if =95008
I byte(optional)	Byte	null byte
80 bytes	Characters	long name
4 bytes	Long Integer	Number of each dimensions
4 bytes per dimension	Long Integers	Dimension sizes
135 bytes	Bytes	Unidentified
Data	Series of two-dimensional tables interspersed with the 84 byte spare block.	

4.7.4 A Visual-Basic program to convert and aggregate the GTAP database:

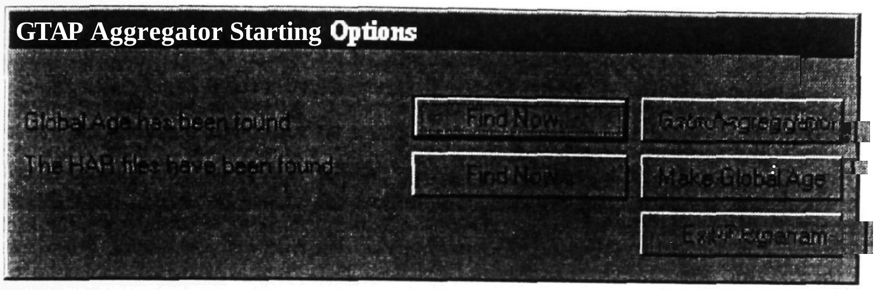
With knowledge of the SALTER parameters and the form that header array files take, it is possible to take the data directly from the file Global.har, convert and aggregate it as needed. Here, a Visual-Basic program is used to do this. GTAPER.EXE has been written for this purpose. A complete discussion of the code used to create GTAPER.EXE will not be given here, since the main parts of the program are derived from the discussions above, and the Visual-Basic code will only be of help to those familiar with the syntax of Visual-Basic.

Because the GTAP data are in the form of a large database, any program that uses it will always take some fime to process the data. GTAPER therefore performs the steps that are required separately, saving the results of each step so that the steps do not need to be repeated unless necessary. There are three main steps performed in the program:

- Header array files are converted into Visual-Basic data types
- An interactive grid allows the user to specify aggregation mappings
- The aggregate data are calculated

When GTAPER starts. the dialog box shown in Figure 4-1 is displayed. GTAPER automatically checks for the liles it needs. but if it does not know the location of them. It must prompt the user to find the files.

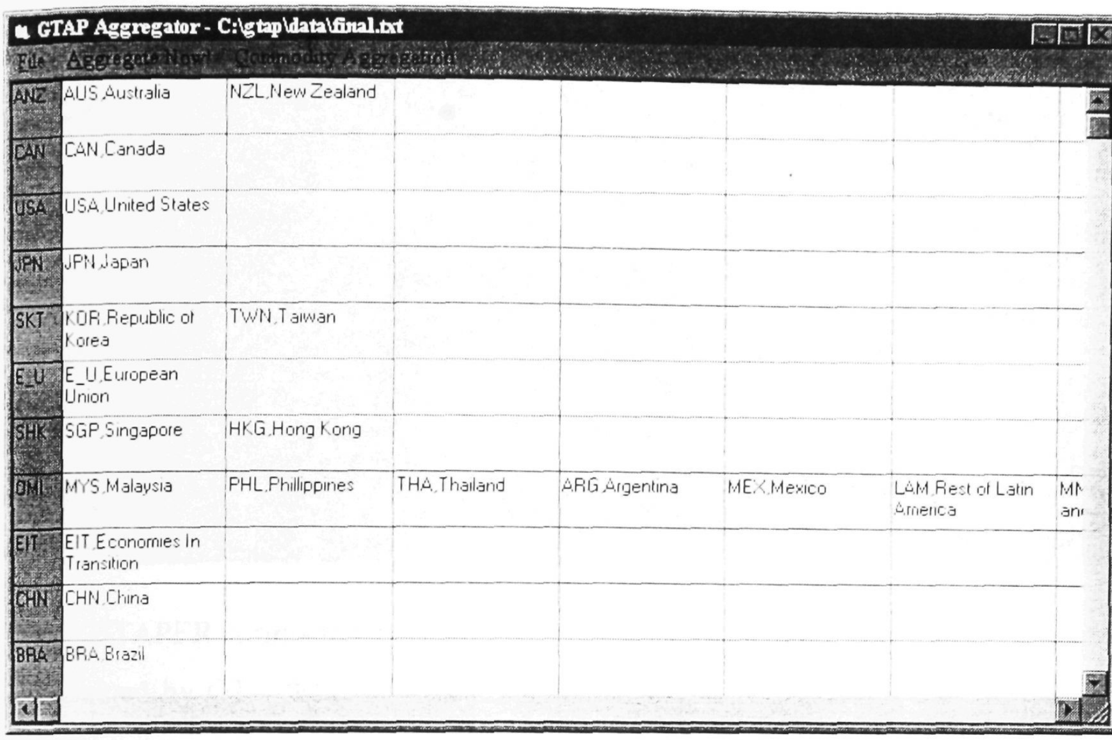
Figure 4-1: GTAPER Start-up Dialog Box



Global.Age is the file into which GTAPER compiles the GTAP database. If it is found. the user can proceed straight to the aggregation part of the program. but if GTAPER has not been run before. the file will not exist and will need to be compiled from header array files. If the option ""Make Global.Age" is chosen. the program will load the header array files using the description of these files given above. calculate the GTAP parameters from the SALTER parameters. and save the GTAP parameters as the file Global,.A,ge, Depending on computer speed. GTAPER will take approximately 1-3 minutes to read the header array files. 1-2 minutes to do the calculations. and just a few seconds to save the file.

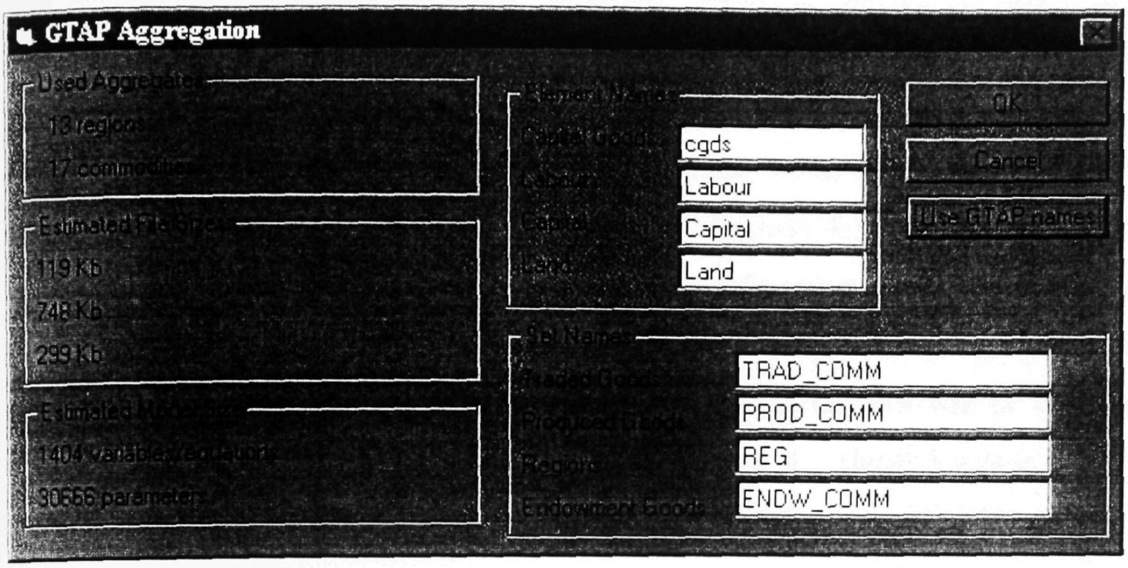
When the database is compiled. the user can proceed to the aggregation. The aggregation grid is shown in Figure 4-2.

Figure 4-2: GTAPER Aggregation Grid



The aggregation grid allows regions or commodities to be assigned to aggregate regions and commodities by clicking and dragging. Aggregate regions and commodities can be renamed. but the disaggregate names can *of* course not be changed. The file menu allows the mappings (with no real data) to be loaded and saved in the standard GT.AP format (aggregation mappings written for the standard (iT,\P aggregator can be loaded in. and files produced by GTAPER can be used in the standard GT.AP aggregation software). When the user has finished, clicking "Aggregate Now" proceeds to the next dialog box. the aggregation summary dialog b(),\ shown in Figure 4-3, This dialog box shows the user details *oi'* the size of the aggregation, and allows set names to be changed. When the user clicks "OK", the program proceeds to the aggregation, which will take approximately 1-3 minutes depending on aggregation size and computer speed. The user is prompted for a filename to save the aggregation file (with the extension "agg").

Figure 4-3: Aggregation Summary Dialog Box



When GTAPER is finished it will start a second program. WINAGE.EXE, loading the file created by GTAPER. WINAGE allows the viewing of headers and their arrays, and allows the export of files as GAMS files. The use of two programs in this way enables checking the values in the aggregation file by viewing it in WINAGE. WINAGE can also be used to load the disaggregate data Global.Age and export it to GAMS.

Other Data Supplied by GTAPER and WINAGE

In addition to the GTAP data outlined above. GTAPER and WINAGE also supply a number of other parameters and subset information.

Additional Parameters

SUBV(i) The elasticity between factors of production in the value-added nest, calculated from the GTAP values given in the file Subst.Har, and aggregated using the total world-wide usage of factors in the given industry as weights.

SUBD(i) The elasticity of substitution between domestic and imported goods, calculated from the GTAP values given in the file Subst.Har. and aggregated using the total world-wide usage of the given good as weights.

SUBM(i) The elasticity of substitution between imported goods from different source regions, calculated from the GTAP values given in the file Subst.Har, and aggregated using the total world-wide imports of the given good as weights.

4.8 CONCLUSIONS

This chapter has examined the GTAP database, version 2. Secfion 4.1 listed the regions and commodities in the database, and section 4.2 introduced sets and parameters in the database, and the accounting relationships between parameters. Section 4.3 discussed the disadvantages of this database, while advantages of GTAP over other databases were discussed in secfion 4.4. Section 4.5 examined in detail database values from global and regional income to trade and agricultural protection in each of the 24 regions, and the elasticity values provided by the database. Section 4.6 discussed aggregation, and developed a certain aggregation that will be used in Chapters 5 and 6 to model the Uruguay Round. Section 4.7 showed details of the methods used to convert the database into a suitable format for use in GAMS.

CHAPTER 5

THE GTAP MODEL AND EXTENSIONS TO THE MODEL

Chapter 5 examines the standard GTAP modelling framework in section 5.1, makes changes to this framework in section 5.2 and extends the model in section 5.3.

5.1 THE STANDARD GTAP MODEL

Hertel (1997) not only contains details of the GTAP database, but also a ftill ('standard') model for use with the database, and a number of applications that use both the database and this standard model.' The standard model is used here as a starting point, and is subsequently modified for use later in this thesis.

5.1.1 The GTAP Model

The standard GTAP model assumes constant returns to scale in all production sectors, and perfect competition in all markets. Factors of production are assumed to be perfectly mobile between sectors in each region, but perfectly immobile 'internationally'.[2] Production requires the use of factor services and of intermediate inputs. There is one 'typical' household in each region which receives the factor rewards and consumes both domestic and imported goods, which are differentiated by region of origin.[3] All policy variables are determined exogenously. with taxes and subsidies modelled in *ad valorem* terms, and non-tariff barriers to trade in terms of their *ad valorem* equivalents.

The definitions of GTAP sets and parameters from chapter 4 are used throughout this chapter. Following the graphical representation of section 3.2, section 5.1.2 defines

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[1] Hertel gives details of the model in linearised (percentage change) form, which can be solved with the GEMPACK software.

[2] Land is only used in agricultural sectors, and can be specified as a 'sticky' factor through the use of a constant elasticity of transformation function.

the standard GTAP model in the MPS/GE language syntax. Section 5.1.3 examines each part of the MPS/GE model in detail, and derives a series of equations, using the pre-calibrated functions derived in section 2-5. Section 5.1.4 discusses various details of the model, and section 5.1.5 concludes with a discussion of the strengths and weaknesses of the GTAP model.

5.1.2 The GTAP Model[4] as an MPS/GE model[5]

There is one important difference between the model presented in table 5-1 and the model presented in Hertel (1997): in table 5-1 private utility is represented as a Cobb-Douglas function, while Hertel uses a Constant-Difference of Elasticity (CDE) function. The advantage of the CDE function is that it allows non-unity income-elasticity of demand and price-elasticity of demand. It is not included here primarily because it cannot be represented in the MPS/GE language.

All variables used below are *multiples*, so that they give a multiple of the relevant benchmark value. As all prices are normalised to unity, the multiple and the price are identical, but for quantity and income variables, the multipliers (always in lower case) should be multiplied by the base value (always in upper case) to obtain the counterfactual quantity. For example, q(j,r) is the output multiple of sector j in region r. while the base output is VOM(j,r) (value of output at market prices). The counterfactual quantity of output is then q(j,r) * VOM(j,r).

Variables appear in lower case while parameters (capitalised) are as defined in chapter 4, but are defined again here for clarity. One additional type of parameter is used: for tax rates a base value of the tax rate is given as a parameter with '0' after the name (i.e. TO0(i,r,s), TX0(i,r,s,), TM0(i,r,s)), while the parameter name without '0' indicates the value of the tax in the simulation.

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[3] The 'Armington' assumption.

[4] See Chapter 3 for a graphical representation of the model,

[5] For details of the MPSGE language, see Rutherford 1993 and 1994, For details of GAMS, the programming system within which MPSGE is implemented, see Brooke, Kendrick and Meeraus 1988. Details are also available via the internet at htpp://www.gams.com

Table 5–1: The Standard GTAP model as an MPS/GE model

```
$SECTORS:
        q(j/r)              ! Output
        va(j,r)             ! Value-added
        fa(i,j,r)           ! Armington output for Firms' use
        pa(i,r)             ! Armington output for Private use
        ga(i,r)             ! Armington output for Government use
        gu(r)               ! Government Utility
        pu(r)               ! Private Utility
        gt                  ! Global Transport
        gs                  ! Global Savings
        wel(r)              ! Regional Welfare
        m(i,r)              ! Composite imports
        ms(i, s, r)         ! Imports by region
        xs(i, s, r)         ! Exports by region
$COMMODITIES:
        p(j,r)              ! Price
        vap(j,r)            ! Aggregate value-added price
        w(f,r)              ! Wage
        fap(i,j,r)          ! Armington Price for Firms' use
        pap(i,r)            ! Armington Price for Private use
        gap(i,r)            ! Armington Price for Government use
        gp(r)               ! Government Price Index
        pp(r)               ! Private Price Index
        gtp                 ! Global Transport Price
        gsp                 '. Global Savings Price
        wpi(r)              '. Welfare Price Index
        mp(i,r)             '. Composite import price
        cifp(i,s, r)        '. Import (cif) price by region
        fobp(i,s,r)         '. Export (fob) price by region
$CONSUMERS
        y(r)                '. Income

$PROD:q(j,r)     s:0
O:p(j,r)       Q:VOM(j,r)      A:y(r)  T:TO(j,r)   P:(1-TOO(j,r))
I:fap(i,j,r)  Q:VFA(i,j,r)
I:vap(j,r)    Q:VVA(j,r)

$PROD:va(j,r)    s:SIGV(j)
O:vap(j,r)    Q:VVA{j,r)
I:w(f,r)      Q:EVFA(f,j,r)

$PROD:fa(i,j,r) s:SIGD(i)
O:fap(i, j,r) Q:VFA(i,j,r)
I:p(i,r)      Q:VDFM(i,j,r) P: (1+TFDO(i,j,r)) A:y(r) T:TFD(i,j,r)
I:mp(i,r)     Q:VIFM(i,j,r) P:(1+TFIO(i,j,r)) A:y(r) T:TFI(i,j,r)
$PROD:pa(i,r)    s: SIGD(i)
O:pap(i,r)    Q:VPA(i,r)
I:p(i,r)      Q:VDPM(i,r) P: (1+TPDO(i,r)) A:y(r) T:TPD(i,r)
I:mp(i,r)     Q:VIPM(i,r) P: (1+TPIO(i,r)) A:y(r) T:TPI(i,r)

$PROD:ga(i,r)    s:SIGD(i)
O:gap(i,r)    Q:VGA(i,r)
I:p(i,r)      Q:VDGM(i,r) P:(1+TGDO(i,r)) A:y(r) T:TGD(i,r)
I:mp(i,r)     Q:VIGM(i,r) P:(1+TGIO(i,r)) A:y(r) T:TGI(i,r)

$PROD:m(i,r)  s:SIGM(i)
O:mp(i,r)      Q:VIM(i,r)
I:cifp(i,s,r) Q:VIWS(i,s, r) P: (1+TMO(i,s,r)) A:y(r) T:TM{i,s,r)

$PROD:ms(i,s,r)   s:0
O:cifp(i,s,r)  Q:VIWS(i,s,r)
```

```
I:fobp(i,s,r) Q:VXWD(i,s,r)
I:gtp          Q:VTWR(i,s,r)

$PROD:xs (i, s, r)
O:fobp(i,s,r)  Q:VXWD(i,s,r)
I:p(i,s)       Q:VXMD(i,s,r) P:(1+TXO(i,s,r)) A:Y(s) T:TX(i,s,r)

$PROD:gu(r)        s:1
O:gp(r)        Q:(sum(i, VGA(i,r)))
I:gap(i,r)     Q:VGA(i,r)

$PROD:pu(r)        s:1
O:pp(r)        Q:(sum(i, VPA(i,r)))
I:pap(i,r)     Q:VPA(i,r)

$PROD:gt            s:0
O:gtp          Q: (sum{ (i,r) ,VST(i,r)))
I:p(i,r}       Q:VST(i,r)

$PROD:gs            s:1
O:gsp          Q: (sum(r,SAVE(r)))
I:p("cgds",r)  Q:((VOM("cgds",r)-VDEP(r)))

$PROD:wel(r)        s:1
O:wpi(r)       Q:(sum(i, VGA(i,r) + VPA(i,r)) + SAVE(r))
I:gp(r)        Q:(sum(i, VGA(i,r)))
I:pp(r)        Q:(sum(i, VPA(i,r)))
I:gsp          Q:SAVE(r)

$DEMAND:y(r)       s:1
E:w(f,r)       Q:(sum[j,EVFA(f,j,r) ] )
E:p("cgds",r)  Q:(-VDEP(r))
D:wDi(r)       Q:(INCOME(r)-VDEP(r))
```

5.1.3 Details of the MPS/GE model

This section examines each part of the MPS/GE model in turn, deriving expressions for output prices and input quantities.

The production sectors: intermediate inputs and value-added

Box 1 shows the details for the top-level production nest; the structure of this box will be used to define other parts of the model below. At the top of the box is the MPS/GE representation of the nest, identical to the relevant part of table 5-1. Below this the equations that correspond to this nest are defined, followed by definitions of variables and parameters. Each equation is labelled with the box number and equation number within the box, with the multiples equations that are used by MPS/GE given first (in this case, equations 1.1 to 1.4) Then levels equations (1.5 to 1.7) define the quantity (upper case) that corresponds to output and input demands in the sector. The variable list contains variables that are defined in the MPS/GE model (table 5-1) and additional variables that are defined here for convenience. MPS/GE does not use variable names for input demands (dfa and dva in box 1), but these will be useful when later

Box 1: Production

```
MPSGE Declaration:

$PROD:q(j,r)       s:0
O:p(j,r)        Q:VOM(j,r)      A:y(r)  T:TO(j,r)    P:(1-TOO(j,r))
I:fap(i,j,r)  Q:VFA(i,j,r)
I:vap(j,r)     Q:VVA(j,r)

Equations:
ps(j,r) = sum[j,  (VFA(i,j,r)/VOA(j,r)) * fap(i,j,r)]
                + (VVA(j,r)   /VOA(j,r))  * vap(j,r)               [1.1]
ps(j,r)         =p(j,r)*(1-TO(j,r))/(1-TOO(j,r))                   [1.2]
dfa(i,j,r)      = q(j,r)                                           [1.3]
dva(j,r)        = q(j,r)                                           [1.4]

Q(j,r)          = q(j,r)xVOM(j,r)                                  [1.5]
DFA(i,j,r)      = dfa(i,j,r)xVFA(i,j,r)                            [1.6]
DVA(j,r)        = dva(j,r)xVVA(j,r)                                [1.7]

Variables:
q(j,r)          Quantity of output for sector j in region r
p(j,r)          Market price of sector j output in region r
fap(i,j,r)      Armington Price for Firms' use
vap(j,r)        Aggregate value-added price
y(r)            Income
dva(j,r)        Demand for value-added in sector j in region r.
dfa(i,j,r)      Firm demand for Armington aggregate good i in sector
                j in region r.
ps(j,r)         Supply price of sector j output in region r.

Parameters:
VOM(j,r)        Value of Output at Market prices
VOA(j,r)        Value of Output at Agents' prices
VFA(i,j,r)      Value of Firm demand for intermediates at Agents'
                prices
VVA(j,r)        Value of Value-Added demand at agents' prices
TO(j,r)         Output tax
TOO(j,r)        Base output tax
```

describing the market clearing conditions of the model. Parameters are defined in chapter 4, but are repeated in each box for convenience.

The production sector in box 1 is a Leontief structure (the elasticity is given by s:0 after the $PROD: declaration - in this nest it is zero) that takes inputs of intermediates. with price fap, and value-added, with price vap, to produce output of goods, with price p. In MPS/GE the 'name' of a good and the price of that good are represented by the same symbol.

Base quantities are given in the Q: field, so that in the base data the sector q(j,r) produces VOM(j,r) of good p(j,r), using VFA(i,j,r) of intennediates fap(i.j,r) and VVA(j,r) of value-added vap(j,r).

Where taxes are applied, a tax agent (the A: field) names a household who will receive the tax payment; in this case the agent is y(r). Just as a the name of a good is used as the price of that good, the name of a household is used as the income level of that household. y(r) is the regional household in region r, and the value y(r) also means the income level of that household. The agent name is followed by a tax parameter (T: field) and a reference price (P: field). The tax parameter defines what tax is applied during model simulation while the reference price defines the price that the sector receives for each unit of output in the base data.[6] In this case each unit of output is taxed at the rate TO(j,r), and since the base tax rate is TO0(j,r) the reference price is 1-TO0(j,r).

Equation 1.1 defines the supply price as a linear combination of input prices. Equation 1.2 links the supply price and market price.[7] Equations 1.3 and 1.4 link the demand for inputs to output, which because this nest is Leontief, are equal.

The levels equations 1.5 to 1.7 link the upper case level of output (1.5) and input quantities (1.6 and 1.7) to the lower case multiples. In each case the level is the multiple times the base quantity.

---

[6] When, as in most other cases in the model, the tax is applied to an input, the reference price is the price paid for that good by the sector in the base data. It is therefore one plus the base tax rate,

[7] If uppercase P(i,r) indicates the price level and P0(j,r) indicates the base level then;

```
         PS(j,r)   =  (1-TO(j,r))    P(j,r)
and      PS0(j,r)  =  (1-TO0(j,r))   P0(j,r)
then     ps(j,r)   =  PS(j,r) / PS0(j,r)
                   =  [P(j,r) / P0(j,r)] (1-TO(j,r))/(1-TO0(j,r))
                   =  p(j,r)  (1-TO(j,r))/(1-TO0(j,r))
where the base market price P0(j,r) = 1
```

Box 2: Value-Added

MPSGE Declaration:

```
$PROD:va(j,r)   s:SIGV(j)
O:vap(j,r)      Q:VVA(j,r)
I:w(f,r)        Q:EVFA(f,j,r)
```

Equations:

vap(j,r)	$= \mathrm{SUM}[f, \mathrm{VASHR}(f,j,r) \times w(f)^{(1-\mathrm{SIGV}(j))}]^{(1/(1-\mathrm{SIGV}(j)))}$	[2.1]
e(f,j,r)	$= va(j,r) \times [vap(j,r)/w(f,r)]^{\mathrm{SIGV}(j)}$	[2.2]
VA(j,r)	$= va(j,r) \times \mathrm{VVA}(j,r)$	[2.3]
E(f,j,r)	$= e(f,j,r) \times \mathrm{EVFA}(f,j,r)$	[2.4]

Variables:

va(j,r)	Quantity of value-added
vap(j,r)	Aggregate value-added price
w(f,r)	Wage
e(f,j,r)	Employment of factor f in sector j of region r

Parameters:

VVA(j,r)	Value of Value-Added demand at agents' prices
EVFA(f,j,r)	Endowment commodity Value of purchases by Firms
SIGV(j)	Elasticity of substitution between factors of production
VASHR(f,j,r)	Share of factor f in value-added in sector j in region r = EVFA(f,j,r)/VVA(j,r)

Production of value-added composites

To add clarity, the value-added nest of the production sector is treated separately here. Later, it will be treated within the production sector itself Box 2 shows the value-added nest.

The elasticity between factors is SIGV(j), indicating a CES production function. Equation 2.1 gives the value-added price, and equation 2.2 gives demand for factors (as a multiple variable). Both these equations are pre-calibrated equations from chapter 2 section 2.5. A new parameter. VASHR, has been declared here in order to make equation 2.1 clearer. Equations 2.3 and 2.4 calculate levels values to be used in market clearing equations.

Box 3: Armington goods for firms' use

MPSGE Declaration::

```
$PROD:fa(i,j,r)  s:SIGD(i)
O:fap(i,j,r)  Q:VFA(i,j,r)
I:p(i,r)      Q:VDFM(i,j,r)  P:(1+TFD0(i,j,r))  A:y(r)  T:TFD(i,j,r)
I:mp(i,r)     Q:VIFM(i,j,r)  P:(1+TFI0(i,j,r))  A:y(r)  T:TFI(i,j,r)
```

Equations:

$$fap(i,j,r) = \left[VDFM(i,j,r)/VFA(i,j,r) \times [p(i,r) \times tfd(i,j,r)]^{(1-SIGD(i))} + VIFM(i,j,r)/VFA(i,j,r) \times [mp(i,r) \times tfi(i,j,r)]^{(1-SIGD(i))} \right]^{(1/(1-SIGD(i)))} \quad [3.1]$$

$$fdd(i,j,r) = fa(i,j,r) \times [fap(i,j,r)/\{p(i,r) \times tfd(i,j,r)\}]^{SIGD(i)} \quad [3.2]$$

$$fdm(i,j,r) = fa(i,j,r) \times [fap(i,j,r)/\{mp(i,r) \times tfi(i,j,r)\}]^{SIGD(i)} \quad [3.3]$$

$$FA(i,j,r) = fa(i,j,r) \times VFA(i,j,r) \quad [3.4]$$

$$FDD(i,j,r) = fdd(i,j,r) \times VDFM(i,j,r) \quad [3.5]$$

$$FDM(i,j,r) = fdm(i,j,r) \times VIFM(i,j,r) \quad [3.6]$$

Variables:

fap(i,j,r)	Armington Price for Firms' use
p(i,r)	Price (for domestic good)
mp(i,r)	Composite import price
fa(i,j,r)	Armington output for Firms' use
fdd(i,j,r)	Firms' demand for domestically sourced goods
fdm(i,j,r)	Firms' demand for imports

Parameters:

VDFM(i,j,r)	Value of Domestic purchases by Firms at Market prices, by commodity, sector and region.
VIFM(i,j,r)	Value of Import; purchases by Firms at Market prices, by commodity, sector and region.
VFA(i,j,r)	Value of Firms' demand at Agents' prices, by comindity, sector and region.
TFD(i,j,r)	Tax on intermediate use of domestic good i used in sector j in region r
TFD0(i,j,r)	Base value of TFD(i,j,r)
TFI(i,j,r)	Tax on intermediate use of imports of good i used in sector j in region r
TFI0(i,j,r)	Base value of TFI(i,j,r)
SIGD(i)	Elasticity of substitution between domestically sourced and imported goods

The following tax *multiples* are used:

$$tfd(i,j,r) = (1+TFD(i,j,r))/(1+TFD0(i,j,r))$$

$$tfi(i,j,r) = (1+TFI(i,j,r))/(1+TFI0(i,j,r))$$

Production of Armington aggregate goods for intermediate use

Armington aggregate goods are 'produced' for three different uses: intermediate use, private consumption, and government consumption. The same elasticities of substitution are used in each case, with only initial quantities and taxes varying between the three different uses.

Box 3 shows the MPS/GE definition of the Armington aggregate for intermediate use, and the corresponding equations with a list of the variables and parameters used in this nest.

Box 4: Private Armington Goods

```
MPSGE Declaration:

$PROD:pa(i, r)     s:SIGD(i)
O:pap d, r)        Q:VPA(i,r)
I:pd,r)            Q:VDPM(i,r)  P: (1+TPD0(i,r) )  A:y(r)  T:TPD(i,r)
I:mp(i,r)          Q:VIPM(i,r)  P: (1+TPI0(i,r))  A:y(r)  T:TPI(i,r)

Equations:
pap(i,r)      =  [VDPM(i,r)/VPA(i,r)x[p(i,r)xtpd(i,r)]^(1-SIGD(i))
                  + VIPM(i,r)/VPA(i,r)x[mp(i,r)xtpi(i,r)]^(1-SIGD(i))
                  }^(1/(1-SIGD(i)))                                   [4.1]
pdd(i,r)      = pa (i, r)x [pap(i,r)/{pd, r)xtpd(i, r) } ]^SIGD(i)     [4.2]
pdm{i,r)      = pa (i, r) x [pap (i, r) / {p(i, r) xtpi (i, r) }]^SIGD(i) [4.3]

PA(i,r)       = VPAd, r) xpad, r)                                     [4.4]
PDDd,r)       = VDPM(i,r)xpdd(i,r)                                    [4.5]
PDM(i,r)      = VIPM(i,r)xpdm(i,r)                                    [4.6]

Variables:
papd, r)      Armington Price for private use
pd,r)         Price (for domestic good)
mp(i,r)       Composite import price
pa(i,r)       Armington output for private use
pdd(i,r)      Private demand for domestically sourced goods
pdm(i,r)      Private demand for imports

Parameters:
VDPM(i,r)     Value of Domestic purchases by private household at
              Market prices, by commodity and region.
VIPM(i,r)     Value of Import purchases by private household at
              Market prices, by commodity and region.
VPA(i,r)      Value of Private demand at Agents' prices, by
              commodity and region.
TFD(i,r;      Tax on private use of domestic good i in region r
TPD0d,r)      Base value of TPDd,r)
TPI(i,r)      Tax on private use of imports of good i in region r
TPI0(i,r)     Base value of TFI(i,r)
SIGD(i)       Elasticity of substitution between domestically
              sourced and imported goods

The following tax multiples are used:
tpd(i,r)      = (1 + TPDd,r) )/(1 + TPD0(i,r))
tpi(i,r)      = (1+TPI(i,r) ) / (1 + TPI0 d, r) )
```

The elasticity SIGD(i) signifies a CES function with that value, unless of course SIGD(i) is set to zero (Leontief) or one (Cobb-Douglas). Equation 3.1 gives the CES pre-calibrated price function, with tax multiples (lower case) used to simplify the expression. These are defined at the bottom of the box, and are equivalent to the power of the taxes.

Equations 3.2 and 3.3 give the pre-calibrated input demands. Note that when a tax on an input is included, it is the agents' price (inclusive of tax) that must be used in these equations. Equations 3.4 to 3.6 give the levels values of output (3.4) and inputs (3.5 and 3.6)

Box 5: Government Armington Goods

```
MPSGE Declaration:

$PROD:ga(i,r)      s:SIGD(i)
O:gap(i,r)      Q:VGA(i,r)
I:p(i,r)        Q:VDGM(i,r)   P:(1+TGDO(i,r))   A:y(r)   T:TGD(i,r)
I:mp(i,r)       Q:VIGM(i,r)   P:(1+TGIO(i,r))   A:y(r)   T:TGI(i,r)

Equations:
gap(i,r)     =  [VDGM(i,r)/VGA(i,r)x[p(i,r)xtgd(i,r)]^(1-SIGD(i))
                 + VIGM(i,r)/VGA(i,r)x[mp(i,r)xtgi(i,r)]^(1-SIGD(i))
                ]^(1/(1-SIGD(i)))                                        [5.1]
gdd(i,r)     =  ga(i,r)x[gap(i,r)/{p(i,r)xtgd(i,r)}]^SIGD(i)             [5.2]
gdm(i,r)     =  ga(i,r)x[gap(i,r)/{mp(i,r)xtgi(i,r)}]^SIGD(i)            [5.3]

GA(i,r)      =  VGA(i,r)xga(i,r)                                         [5.4]
GDD(i,r)     =  VDGM(i,r)xgdd(i,r)                                       [5.5]
GDM(i,r)     =  VIGM(i,r)xgdm(i,r)                                       [5.6]

Variables:
gap(i,r)        Armington Price for government use
p(i,r)          Price (for domestic good)
mp(i,r)         Composite import price
ga(i,r)         Armington output for government use
gdd(i,r)        Government demand for domestically sourced goods
gdm(i,r)        Government demand for imports

Parameters:
VDGM(i,r)       Value of Domestic purchases by government household
                at Market prices, by commodity and region.
VIGM(i,r)       Value of Import purchases by government household at
                Market prices, by commodity and region.
VGA(i,r)        Value of Government demand at Agents' prices, by
                commodity and region.
TGD(i,r)        Tax on government use of domestic good i in region r
TGDO(i,r)       Base value of TGD(i,r)
TGI(i,r)        Tax on government use of imports of good i in region
                r
TGIO(i,r)       Base value of TGI(i,r)
SIGD(i)         Elasticity of substitution between domestically
                sourced and imported goods

The following tax multipliers are used:

tgd(i,r)     =  (1+TGD(i,r))/(1+TGDO(i,r))
tgi(i,r)     =  (1+TGI(i,r))/(1+TGIO(i,r))
```

***Production of Armington aggregate goods for private and government** use*

These sectors follow the form of the intermediate Armington above. Box 4 shows the MPSGE declaration, equations, variables, and parameters for private Armington aggregate goods, and box 5 shows the same for government Armington aggregate goods.

Box 6: Composite Imports

MPSGE Declaration:

```
$PROD:m(i,r)    s:SIGM(i)
G:mp(i,r)       Q:VIM(i,r)
I:cifp(i,s,r)   Q:VIWS(i,s,r) P:(1+TM0(i,s,r)) A:y(r) T:TM(i,s,r)
```

Equations:

$$mp(i,r) = \left[\sum_s MSHR(i,s,r)\times[cifp(i,s,r)\times tm(i,s,r)]^{(1-SIGM(i))}\right]^{(1/(1-SIGM(i)))} \qquad [6.1]$$

$$dm(i,s,r) = m(i,r)\times[mp(i,r)/(cifp(i,s,r)\times tm(i,s,r))]^{SIGM(i)} \qquad [6.2]$$

$$M(i,r) = m(i,r)\times VIM(i,r) \qquad [6.3]$$

$$DM(i,s,r) = dm(i,s,r)\times VIWS(i,s,r) \qquad [6.4]$$

Variables:

m(i,r)	Composite imports (quantity)
mp(i,r)	Composite import price
cifp(i,s,r)	Import (cif) price by region
dm(i,s,r)	Demand for imports from region s
y(r)	Income; the destination region receives tariff payments

Parameters:

VIWS(i,s,r)	Value of Imports at World (c.i.f.) prices, by commodity, source region s and destination region r.
VIM(i,r)	Value of Imports at Market prices, by commodity and region.
TM(i,s,r)	Import tariff by commodity, source and destination
TM0(i,s,r)	Base value of TM(i,s,r)
SIGM(i)	Elasticity of substitution between imports from different source regions
MSHR(i,s,r)	Share of imports of good i into region r that are sourced from region s (evaluated at domestic prices) = VIWS(i,s,r)×(1+TM0(i,s,r)) / VIM(i,r)

The following tax *multiple* is used:

$$tm(i,s,r) = (1+TM(i,s,r))/(1+TM0(i,s,r))$$

Composite Imports

Composite imports are 'made' from imports from different sources. The composite import sector also adds the appropriate import tariff TM(i.r,s) onto the cif price of imports. The elasticity of substitution SIGM(i) means that the nest is CES. Equation 6.1 in box 6 is the CES pre-calibrated price equation, with the weights MSHR (defined in the parameters section of box 6). Equation 6.2 gives the demand for imports on each bilateral route, with equations 6.3 and 6.4 converting multiples to levels.

Box 7: cif Imports

```
MPSGE Declaration:
$PROD:ms(i, s, r)  s:0
O:cifp(i, s, r)  Q:VIWS(i,s,r)
I:fobp(i, s, r)  Q:VXWD(i,s,r)
I:gtp            Q:VTWR(i,s,r)
Equations:
cifp(i,s,r)     = CIFP(i,s,r) / CIFP0(i,s,r)                           [7.1]
CIFP(i,s,r)     = TSHR(i,s,r)xgtp + (1-TSHR(i,s,r))xfobp(i,s,r)        [7.2]
CIFP0(i,s,r)    = TSHRd,s,r)+(l-TSHR(i,s,r))xFOBP0d,s,r)               [7.3]
MS(i,s,r)       = VIWS(i,s,r)xms(i,s,r)                                [7.4]
DFOB(i,s,r)     = VXWD(i,s,r)xms(i,s,r)                                [7.5]
DTRAN(i,s,r)    = VTWR(i,s,r)xms(i,s,r)                                [7.6]
Variables:
ms(i,s,r)        Imports by region
cifpd,s,r)       Import (cif) price by source-destination region pair
fobp(i,s,r)      Export (fob) price by source-destination region pair
gtp              Global transport price
DFOB(i,s,r)      Demand for fob exports
DTRAN(i,s,r)     Demand for transport services
Parameters:
VXWD(i,s,r)      Value of exports at World (fob) prices, by commodity,
                 source region s and aestination region r.
VIWS(i,s,r)      Value of Imports at Worid (c.i.f.) prices, by
                 commodity, source region s and destination region r.
VTWR(i,s,r)      Value of Transport services used in the transport of
                 goods from source region s to destination region r.
                 = VIWS(i,s,r) - VXWD(i,s,r)
TSHR(i,s,r)      Transport share of cif value
                 = VTWR(i,s,r) / VIWS(i,s,r)
```

cif Imports

The cif imports add transport costs to the fob value of the trade flow of good i from source region s to destination region r. Here the convention of uppercase characters for levels, with '0' indicating base values, for (lowercase) multiple variables is extended to cifp and fobp. cifp is. like all prices, normalised to unity; this is done by equadon 7.1, with the 'levels" price CIFP determined in equation 7.2 and the base price determined by equation 7.3. Equations 8.2 and 8.3 in box 8 give the fob prices FOBP and FOBPO, and from these equations the normalised cif price is

$$cifp(i,s,r) = \frac{TSHR(i,s,r)\times gtp + (1 - TSHR(i,s,r)) \times \left(1 + TX(i,s,r)\right) \times P(i,r)}{TSHR(i,s,r) + \left(1 - TSHR(i,s,r)\right) \times \left(1 + TX0(i,s,r)\right)}$$

which could be used in the model in place of equations 7.1, 7.2, 7.3, 8.1, 8.2 and 8.3. The conventions used in boxes 7 and 8 are for clarity only.

Box 8: fob Exports

MPSGE Declaration:

```
$PROD:xs(i,s,r)
O:fobp(i,s,r)   Q:VXWD(i,s,r)
I:p(i,s)        Q:VXMD(i,s,r) P:(1+TX0(i,s,r)) A:y(s) T:TX(i,s,r)
```

Equations:

fobp(i,s,r)	= FOBP(i,s,r) / FOBP0(i,s,r)	[8.1]
FOBP(i,s,r)	= p(i,s)x(1+TX(i,s,r))	[8.2]
FOBP0(i,s,r)	= 1+TX0(i,s,r)	[8.3]
XS(i,s,r)	= VXWD(i,s,r) x xs(i,s,r)	[3.4]
DX(i,s,r)	= VXMD(i,s,r) x xs(i,s,r)	[8.5]

Variables:

fobp(i,s,r)	Export (fob) price by source-destination region pair
p(i,r)	Price
xs(i,s,r)	Exports by source and destination
DX(i,s,r)	Demand for exports in source region s
y(s)	Income; the source region receives export tax payments

Parameters:

VXMD(i,s,r)	Value of exports at Market prices of exporting region, by commodity, source region s and destination region r.
VXWD(i,s,r)	Value of exports at World (fob) prices, by commodity, source region s and destination region r.
TX(i,s,r)	Export tariff by commodity and source-destination regional pairing
TX0(i,s,r)	Base value of TX(i,s,r)

fob Exports

The fob export structure adds any export tax (subsidy) TX(i,s,r) to the domestic price p(i,s) of good i in source region s. for export to destination region r (equation 8.2), with the normalised fob price given by equation 8.1. Equations 8.4 and 8.5 define levels values for exports at world and domestic prices. The (lower case) variable dx(i.s.r) is not included here for brevity; it is equal to xs(i,s,r).

Box 9: Government Utility

MPSGE Declaration:	
\$PROD:gu(r)	s:1
O:gp(r)	Q:GOVEXP(r)
I:gap(i,r)	Q:VGA(i,r)
Equations:	
gp(r)	$= \prod_i gap(i,r)^{GSHR(i,r)}$ [9.1]
gd(i,r)	$= gu(r) \times gp(r) / gap(i,r)$ [9.2]
GU(r)	$= GOVEXP(r) \times gu(r)$ [9.3]
GD(i,r)	$= gd(i,r) \times VGA(i,r)$ [9.4]
Variables:	
gu(r)	Government Utility
gp(r)	Government Price Index
gap(i,r)	Armington Price for Government use
gd(i,r)	Government demand for goods
Parameters:	
VGA(i,r)	Value of Government demand at Agents' prices, by cominodity and region.
GOVEXP(r)	Total government expenditure $= \sum_i VGA(i,r)$
GSHR(i,r)	Share of government expenditure spent on gcoa i $= VGA(i,r) / GOVEXP(r)$

Government Utility

Government utility is a Cobb-Douglas function of the government Armington aggregate goods. Equation 9.1 gives the Cobb-Douglas pre-calibrated function for an aggregate government price index. Equation 9.2 is a pre-calibrated demand function. Equations 9.3 and 9.4 calculate levels values.

Box 10: Private Utility

MPSGE Declaration:

```
$PROD:pu(r)       s:1
O:pp(r)           Q:PRIVEXP(r)
I:pap(i,r)        Q:VPA(i,r)
```

Equations:

pp(r)	$= \prod_i pap(i,r)^{PSHR(i,r)}$	[10.1]
pd(i,r)	$= pu(r) \times pp(r)/pap(i,r)$	[10.2]
PU(r)	$= pu(r) \times PRIVEXP(r)$	[10.3]
PD(i,r)	$= pd(i,r) \times VPA(i,r)$	[10.4]

Variables:

pu(r)	Private Utility
pp(r)	Private Price Index
pap(i,r)	Armington Price for Private use
pd(i,r)	Private demand for goods

Parameters:

VPA(i,r)	Value of Private demand at Agents' prices, by commodity and region.
PRIVEXP(r)	Total private expenditure $= \sum_i VPA(i,r)$
PSHR(i,r)	Share of private expenditure spent on good i $= VPA(i,r) / PRIVEXP(r)$

Private Utility

The private utility function is similar to the government utility function; Equation 10.1 calculates an aggregate private price index in the same manner that equation 9.1 calculates an aggregate government price index.

Box 11: Global Transport

MPSGE Declaration:		
$PROD:gt	s:0	
O:gtp	Q:VT	
I:p(i,r)	Q:V3T(i,r)	

Equations:		
gtp	$= \sum_{i,r}$ SHRT(i, r) $\times$ p(i, r)	[11.1]
GT	= gt×VT	[11.2]
TDEM(i,r)	= gt×VST(i,r)	[11.3]

Variables:	
gt	Global Transport (quantity of total transport services)
gtp	Global Transport Price
p(i,r)	Price of good i in region r
TDEM(i,r)	Transport demand for services

Parameters:	
VST(i,r)	Value of Sales to international Transport, by commodity ana region.
VT	Total transport sales worldwide $= \sum_{i,r}$VST(i, r)
SHRT(i,r)	Share of transport services that are sourced as good i in region r = VST(i,r) / VT

Global Transport

Global transport is a Leontief/fixed coefficients function of individual goods' prices. Equation 11.1 defines the price index for global transport, as a composite of all market prices in all regions. The parameter VST, value of sales to international transport, contains mainly zeros - only the GTAP commodity "T_T trade and transport services" is sold to the global transport sector.

Demand for commodities for use in transport, TDEM(i.r). is a fixed proportion of the quantity of global transport services, as shown in equation 11.3.

Box 12: Global Savings

```
MPSGE Declaration:

$PROD:gs              s:1
O:gsp                 Q:GLOBINV
I:p("cgds",r)         Q:NETINV(r)

Equations:
gsp             = Π_r p("cgds",r)^SHRS(r)                          [12.1]

GS              = gs×GLOBINV                                       [12.2]
SAVDCAP(r)      = gs×gsp/p("cgds",r)×NETINV(r)                     [12.3]

Variables:
gs               Global Savings quantity
gsp              Global Savings Price
p("cgds",r)      Price of capital goods in region r
SAVDCAP(r)       Savings demand for capital in region r

Parameters:
GLOBINV          Value of global investment.
NETINV(r)        Net investment in region r
                 = REGINV(r) - VDEP(r)
SHRS(r)          Share of global savings invested in region r
                 = NETINV(r) / GLOBINV
```

Global Savings

Global savings is a Cobb-Douglas function of capital goods in different regions. Note that capital goods ("cgds")[8] are a member of the set j (produced commodities) but not the set i (tradable commodities). A production sector (box 1) therefore exists for this commodity, although no factors are used in its creation. The parameter VFA(i,j,r) defines the value of firms" demands for goods (and is calculated from the value of firms' demand for imports at agents" prices. VIFA(i,j,r), and the value of firms' demand for domestic goods at agents" prices, VDFA(i,j,r) in chapter 4). Capital goods are just one element of the set j, so the values VFA(i,"cgds",r) give the capital composition matrix, which determines which goods (i) are purchased when capital is formed in region r. A fixed quantity of capital is purchased by the regional household to cover depreciation, and all other capital sales are purchased by global savings.

---

[8] Note that capital goods ("cgds") and (factor) capital are not the same concept. Factor capital refers to existing capital stock while capital goods refers to new capital formation. In the static model there is no link between the two.

Box 13: Regional Welfare

MPSGE Declaration:		
\$PROD:wel(r)	s:1	
O:wpi(r)	Q: (INCOME(r)-VDEP(r))	
I:gp(r)	Q:GOVEXP(r)	
I:pp(r)	Q: PRIVEXP(r)	
I:gsp	Q: (SAVE(r)-VDEP(r))	
Equations:		
wpi(r)	$= gp(r)^{RSHRG(r)} \times pp(r)^{RSHRP(r)} \times gsp^{RSHRS(r)}$	[13.1]
dag(r)	= wel(r) × wpi(r)/gp(r)	[13.2]
dap(r)	= wel(r) × wpi(r)/pp(r)	[13.3]
das(r)	= wel(r) × wpi(r)/gsp	[13.4]
WEL(r)	= wel(r) × (INCOME(r)-VDEP(r))	[13.5]
DAG(r)	= dag(r) × GOVEXP(r)	[13.6]
DAP(r)	= dap(r) × PRIVEXP(r)	[13.7]
DAS(r)	= das(r) × (SAVE(r)-VDEP(r))	[13.8]
Variables:		
wel(r)	Regional Welfare	
wpi(r)	Welfare Price Index	
pp(r)	Private Price Index	
gp(r)	Government Price Index	
gsp	Global Savings Price	
dag(r)	Demand for aggregate government goods	
dap(r)	Demand for aggregate private goods	
das(r)	Demand for savings	
Parameters:		
INCOME(r)	Regional Income, by region	
SAVE(r)	Value of net savings, by region.	
VDEP(r)	Value of capital depreciation, by region.	
GOVEXP(r)	Total government expenditure $= \sum$ VGA(i,r)	
PRIVEXP(r)	Total private expenditure $= \sum$ VPA(i, r)	
RSHRP(r)	Share of private expenditure in total regional expenditure = PRIVEXP(r) / (INCOME(r)-VDEP(r))	
RSHRG(r)	Share of government expenditure in total regional expenditure = GOVEXP(r) / (INCOME(r)-VDEP(r))	
RSHRS(r)	Share of savings in total regional expenditure = SAVE(r) / (INCOME(r)-VDEP(r))	

Regional Welfare

Regional welfare is a Cobb-Douglas function of three different functions: private utility, government utility, and savings. The definition of welfare wel(r) in this manner allows welfare changes to be calculated easily, and makes the assumption that welfare is cardinal. Welfare wel(r) is a multiples variable, so the percentage change in welfare from the base can be found as wel%(r) = 100 * (wel(r) - 1)

while the equivalent variation is EV(r) = WEL(r) - (INCOME(r)-VDEP(r))

= (wel(r) - 1) × (INCOME(r)-VDEP(r))

Box 14: Regional Income

MPSGE Declaration:

```
$DEMAND:y(r)        s:1
E:w(f,r)            Q:EVOA(f,r)
E:p("cgds",r)       Q:(-VDEP(r))
D:wpi(r)            Q:(INCOME(r)-VDEP(r))
```

Equations:

$$
\begin{aligned}
Y(r) = \; & \textstyle\sum_f EVOA(f,r) \times w(f,r) \\
& - VDEP(r) \times p(\text{"cgds"},r) \\
& + \textstyle\sum_j TO(j,r) \times Q(j,r) \times p(j,r) \\
& + \textstyle\sum_{i,j} TFD(i,j,r) \times FDD(i,j,r) \times p(i,r) \\
& + \textstyle\sum_{i,j} TFI(i,j,r) \times FDM(i,j,r) \times mp(i,r) \\
& + \textstyle\sum_i TPD(i,r) \times PDD(i,r) \times p(i,r) \\
& + \textstyle\sum_i TPI(i,r) \times PDM(i,r) \times mp(i,r) \\
& + \textstyle\sum_i TGD(i,r) \times GDD(i,r) \times p(i,r) \\
& + \textstyle\sum_i TGI(i,r) \times GDM(i,r) \times mp(i,r) \\
& + \textstyle\sum_{i,s} TM(i,s,r) \times DM(i,s,r) \times CIFP(i,s,r) \\
& + \textstyle\sum_{i,s} TX(i,r,s) \times DX(i,r,s) \times p(i,r)] \qquad [14.1]
\end{aligned}
$$

$$DWEL(r) = Y(r) \,/\, wpi(r) \qquad [14.2]$$

$$Y(r) = y(r) \times INCOME(r) \qquad [14.3]$$

Variables:

y(r)	Income
wpi(r)	Welfare Price Index
p(i,r)	Price
w(f,r)	Wage
mp(i,r)	Composite import price
cifp(i,s,r)	Import (cif) price by region
DWEL(r)	Demand for welfare good (wpi)

Parameters:
See boxes 1, 3, 4, 5, 6, 7, 8, 13

Regional Income

Regional income is the most complex function to give in equation form, although in MPS/GE form it is simpler, as MPS/GE automatically assigns all tax revenues to the tax agent given in the A: field of the relevant production block.

Income (equation 14.1) is composed of factor income and tax income. For each tax instrument, the tax revenue is calculated as the tax rate multiplied by the base quantity multiplied by the price and output multiples of the relevant output or input. Note that the upper case variable names in equation 14.1 (Q,FDD,FDM,etc.) are levels values: MPS/GE does not use these variables, but substitutes the relevant expression from the producdon nests. DX(i,r,s), the quantity of exports by commodity and bilateral route, is equal to VXMD(i,s,r)xxs(i,s,r) [equation 8.5 in box 8], and this expression is automatically used by MPS/GE in the last term of equation 14.1.

Demand-Supply Equations

One of the advantages of MPS/GE to the user is that it automatically calculates market equilibria equations, but here the equations will be presented in full. To find the equilibrium equations, place all supplies of a commodity on the left of the equation, and all demands of that commodity on the right hand side.

Equation 15.1: Equilibrium for tradable goods markets (p(i,r))

$$Q(i,r) = PDD(i,r) + GDD(i,r) + \sum_j FDD(i,j,r) + TDEM(i,r) + \sum_s DX(i,s,r) \quad [15.1]$$

where		[see equation]
Q(j,r)	Quantity of output for sector j in region r	1.5
PDD(i,r)	Private demand for domestically sourced goods	4.5
GDD(i,r)	Government demand for domestically sourced goods	5.5
FDD(i,j,r)	Firms' demand for domestically sourced goods	3.5
TDEM(i,r)	Transport demand for services	11.3
DX(i,s,r)	Demand for exports in source region s	8.5

Equation 15.1 equates supply and demand for tradable goods i in region r. In this case, supply is output Q(i,r), and demand is the sum of private demands (PDD), government demands (GDD), firms" demands (FDD), the global transport sector's demand for goods (TDEM) and export demand (DX). Note that the number of the equation where each variable is defined appears to the right of the variable explanation.

Equation 15.2 equates the supply of capital goods with demand for capital goods; demand for capital goods comes from global savings (box 12), and a fixed amount of depreciation, the payment for which is deducted from regional income (box 14).

Equation 15.2: Equilibrium for capital goods markets (p("cgds",r))

$$Q(\text{"cgds"},r) = SAVDCAP(r) + VDEP(r) \quad [15.2]$$

where		[see equation]
SAVDCAP(r)	Savings demand for capital in region r	12.3
VDEP(r)	Depreciation (database parameter)	

Equation 15.3 simply equates the supply and demand for value-added in each sector.

Equation 15.3: Equilibrium for composite value-added (vap(j,r))

$$VA(j,r) = DVA(j,r)$$

Where		[see equation]
VA(j,r)	Quantity of value-added	2.3
DVA(j,r)	Demand for value-added in sector j in region r.	1.7

Equation 15.4: Equilibrium for factor markets (w(f,r))

$$EVOA(f,r) = \sum E(f,j,r) \qquad [15.4]$$

where		[see equation]
E(f,j,r)	Employment of factor f in sector j of region r	2.4
EVOA(f,r)	Endowment commodity Value of Output at Agents' prices (database parameter)	

The factor markets (equation 15.4) are central to the model, as many of the traditional general equilibrium effects that the CGE model aims to capture are transmitted through these markets. The supply of factors is a fixed parameter EVOA(f,r) - one of the original database parameters.

The markets for Armington goods are shown in equations 15.5 to 15.7. These are simple one-to-one equations. linking output of the Armington nests with aggregate demand for products from private expenditure, government expenditure, and intermediate demand.

Equations 15.5 to 15.7: Equilibrium for Armington markets (fap(i,j,r), pap(i,r) and gap(i,r))

$$FA(i,j,r) = DFA(i,j,r) \qquad [15.5]$$
$$PA(i,r) = PD(i,r) \qquad [15.6]$$
$$GA(i,r) = GD(i,r) \qquad [15.7]$$

where		[see equation]
FA(i,j,r)	Armington output for Firms' use	3.3
DFA(i,j,r)	Firm demand for Armington aggregate	1.6
PA(i,r)	Armington output for private use	4.4
PD(i,r)	Private demand for goods	10.4
GA(i,r)	Armington output for government use	5.4
GD(i,r)	Government demand for goods	9.4

Equation 15.8 equates total supply of global transport with the demand for transport services on each bilateral trade route for each commodity.

Equation 15.8: Equilibrium for Global Transport (gtp)

$$GT = \sum_{i,s,r} DTRAN(i,s,r) \qquad [15.8]$$

where		[see equation]
GT	Global Transport (quantity of transport services)	11.2
DTRAN(i,s,r)	Demand for transport services	7.6

Equation 15.9: Equilibrium for Global Savings (gsp)

$$GS = \sum_r DAS(r) \qquad [15.9]$$

where		[see equation]
GS	Global Savings quantity	12.2
DAS(r)	Demand for savings	13.8

Equilibrium for global savings (equation 15.9) equates the total supply of global savings with the demand for savings in each region.

Equation 15.10 equates the 'supply" of welfare to the 'demand' for welfare.

Equation 15.10: Equilibrium for aggregate welfare (wpi(r))

$$WEL(r) = DWEL(r) \qquad [15.10]$$

where		[see equation]
WEL(r)	Regional Welfare	13.5
DWEL(r)	Demand for welfare good (wpi)	14.2

Equation 15.11 equates import supply and demand. Import supply M(i,r) is total (composite) imports of good i into region r, and is a CES aggregate of imports from different source regions, as detailed in box 6. Import demand is from the private, government and intermediate Armington nests. If the Armington structure is envisaged as a two stage nest, with substitution between domestic goods and import goods in the top nest, and substitution between imports from different source regions in the lower nest, then equation 15.11 occurs in between the nests.[9]

Equation 15.11: Equilibrium for aggregate imports (mp(i,r))

$$M(i,r) = PDM(i,r) + GDM(i,r) + \sum_j FDM(i,j,r) \qquad [15.11]$$

where		[see equation]
M(i,r)	Composite imports (quantity)	6.3
FDM(i,j,r)	Firms' demand for imports	3.6
PDM(i,r)	Private demand for imports	4.6
GDM(i,r)	Government demand for imports	5.6

Equation 15.12 enforces the condition that demand for imports in box 6 equals the supply of imports in box 7, both on a bilateral basis.

Equation 15.12: Equilibrium for imports (cifp(i,s,r))

$$MS(i,s,r) = DM(i,s,r) \qquad [15.12]$$

where		[see equation]
MS(i,s,r)	Imports by region	7.4
DM(i,s,r)	Demand for imports from region s	6.4

[9] As described diagrammatically in figures 3-2, 3-3 and 3-4 of chapter 3.

Equation 15.13: Equilibrium for exports (fobp(i,s,r))		
XS(i,s,r)	= DFOB (i, s, r)	[15.13]
where		[see equation]
DFOB(i, s, r)	Demand for fob exports	7.5
XS(i,s,r)	Exports by source and destination	8.4

Similarly, the demand for exports in box 7 must equal the supply of exports in box 8, as ensured by equation 15.13.

5.2 MODEL CHANGES

There are several changes that are made to the GTAP model that are not strictly extensions, and they are dealt with here; extensions to the model are detailed in section 5.3. Changes to the model are detailed in MPS/GE only.

5.2.1 Changes to Private Preferences

The model presented in section 5.1 already has one change made to private preferences: here private preferences are Cobb-Douglas, but in the standard GTAP model using the GEMPACK software, preferences use the Constant Differences of Elasticities (CDE) function.[10]

The GTAP model uses calibrated parameters for EP (price elasticity) and EY (income elasticity) to apply the CDE function. The linearised demand function for privately demanded goods is:

qpd%(i,r) = sum[k, EP(i,k,r) pap%(k.r)] + EY(i,r) yp%(r)

corresponding to a levels-multiples form:

qpd(i,r) = prod[k, pap(k.r)**EP(i,k.r)] * yp(r)**EY(i,r)

The CDE linearised function is:

py%(r) = sum[i, s(i,r) pap%(i,r) + s(i,r) e(i.r) pu%(r)]

corresponding to the levels-multiples equation:

10 Chapter 2 contains details of this function.

$$py(r) = sum[i. u(r)**[e(i,r)b(i,r)] * pap(i,r)**b(i,r)]$$

Calibrating the CDE function

Calibration of the CDE function is complex. Four parameters are calibrated for use in the GTAP model: EP(i,k,r), EY(i,r), e(i,r) and b(i,r). These parameters are not however independent. Once the elasticity parameters EP and EY are calibrated, they determine the CDE parameters e and b. Furthermore, EP and EY are not independent, and must conform to overall homogeneity constraints. Additionally, there is a further problem in that calibration does not necessarily ensure that all b_i are either positive or all negative. Because of the last problem, the GTAP calibration procedure uses target own-price and income elasticities, and employs a non-linear minimisation procedure. The resulting elasticities are in most cases very close to the target elasticities, but can diverge significantly for goods with high expenditure shares. No target elasticities are used for cross-price elasticities, or for elasticities of substitution - it is left entirely to the calibration procedure to determine values that are consistent with the targeting of income and own-price elasticities.

Strengths and weaknesses of the CDE function

The CDE function is a more flexible functional form than functions used more commonly in CGE modelling - the Leontief Cobb-Douglas, constant elasticity of substitution (CES). and linear expenditure system (LES). It is also more tractable than other functional forms. More flexible functions, such as translog and Constant Ratios of Elasticities nomothetic (CRESH), are rarely used due to their complexity and data-intensity.

The main weakness of the CDE function in the GTAP model/database is the way it is calibrated. The target income and own-price elasticities are taken from the SALTER model, and were originally estimated in the 1970s for smaller sets of regions and commodities than are used in GTAP. The inability to determine target cross-price elasticities, and the occasional large divergences from target and calibrated values for income and own-price elasticities, are further drawbacks.

Even given these drawbacks, the ability to use income and own-price elasticity targets is a major advantage over less flexible functional forms, although it should be noted that the actual elasticities diverge even further from the target elasticities when income and price changes are large. This is because the relationships that the CDE parameters b_i and e_i have with the elasticity parameters are dependent on the expenditure shares. Thus as expenditure shares differ from their benchmark levels, the CDE parameters imply different elasticities than they do at the benchmark. While the traditional critique of less flexible functional forms such as Cobb-Douglas and CES is that they perform badly in simulations that involve large changes in income, any such simulation conducted with a CDE function will have unpredictable elasticity effects.

5.2.2 Changes to the Armington Structure

The Armington nesting structure of the "standard" GTAP modelling framework uses a two-level nest for each consuming agent (government, private demand, capital goods and each tradable-good industry). This approach leads to a problem with the number of variables that the model needs for solution: the Armington nests alone need a price variable and a quantity variable for each nest. The model structure of section 5.1.3 needs 2x(nx(3+m)xm) variables for a model with n regions and m tradable commodities. For the 13-region, 17-commodity model used here, this would imply 8,840 variables, which would make the solution of such a large-scale model prohibitive (the final model uses less than 2,000 variables for the whole model). The solution used here follows Harrison (1997)[11] in defining a single Armington aggregate for each commodity in each region, which is used by private, government, and intermediate demand in the same region. Box 16 shows each step required to make this change.

[11] This model, and Harrison *et al.* 1995 and Francois *et al.* 1994 and 1995a all use MPSGE to model GTAP. Each uses this compression of the Armington structure (and incidentally, none use CDE preferences).

Box **16: Steps to Compress Armington Structure**

```
1) Create a new Armington nest a(i,r) and good ap(i,r)
$PROD:a(i,r)  s:SIGD(i)
O:ap(i,r)     Q:VAA(i,r)
I:p(i,r)      Q:VDA(i,r)
I:mp(i,r)     Q:VIA(i,r)

Mew Variables:
a(i,r)          Armington Aggregate Output
ap(i,r)         Armington Price

New Parameters:
VAA(i,r)        Value of Armington Aggregate use
                = VPA(i,r) + VGA(i,r) + Σj VFA(i,j,r)
VDA(i,r)        Value of Armington Domestic use
                = VDPA(i,r) + VDGA(i,r) + Σj VDFA{i,j,r)
VIA(i,r)        Value of Armington Import use
                = VIPA(i,r) + VIGA(i,r) + Σj VIGA(i,j,r)
```

```
2) Remove the Armington nests pa(i,r),ga(i,r),fa(i,j,r)
       and remove the goods pap(i,r),gap(i,r),fap(i,j,r)
```

```
3) Replace the output nest (see oox 1) with the following:
$PROD:q(j,r)    s:0
O:p(j,r)      Q:VOM(j,r)     A:y(r) T:TO(j,r)   P:(1-TOO(j,r) )
I:ap(i,j,r)   Q:VFM(i,j,r) A:y(r) T:TF(i,j,r) P : ( 1 + TFO (i , j , r ))
I:vap(j,r)    Q:VVA(j,r)

Parameter:
TF(i,j,r)      Average tax on intermediate use of domestic + import
               goods
```

```
4) Replace the Government Utility nest (see box 9) with the
following:
$PROD:gu(r)     s:l
O:gp(r)       Q: (sum(i, VGA(i,r) ) )
I:ip(i,r)      Q:VGM(i,r)    P:(1+TGO(i,r))   A:Y(r)  T:TG(i,r)

Parameter:
TG(i,r)        Average tax on government use of domestic + import
               goods
```

```
5) Replace the Private Utility nest (see box 10) with tne following
$PROD:pu(r)     s:l
0:pp(r)        Q: (sumd, VPA(i,r)))
I:ap(i,r)      Q:VPM(i,r)    P: (1+TPO(i,r))   A:Y(r)  T:TP(i,r)

Parameters:
TP(i,r)        Average tax on private use of domestic + import goods
```

This structure replaces the three structures pa(i,r), ga(i,r) and fa(i,j,r). The good produced by this Armington structure. ap(i,r) replaces the separate Armington aggregates pap(i,r), gap(i,r) and fap(i,j,r). The by-use taxes TPI(i,r), TPD(i,r), TGI(i,r), TGD(i,r), TFI(i,j,r) and TFD(i,j,r) are not included in this nest; each user of the Armington product pays a by-use tax on the Armington consumption as a whole. The new taxes are TP(i,r) for private consumption taxes, TG(i,r) for government consumption taxes, and TF(i,j,r) for intermediate use taxes. The initial levels of these new taxes are averages of the benchmark levels of the previous taxes. Some detail is thus lost, as differences in the by-use taxes for imported and domestic goods are ignored.

A by-use tax for imports can be different from the corresponding by-use tax for domestic goods in the GTAP database, although this is mainly due to different compositions of the goods. As such, all the GTAP applications cited in previous chapters do not change the by-use taxes as a result of tariff changes. The main reason that these taxes would be needed separately in the Uruguay Round context is to change input subsidies for agricultural inputs.

5.2.3 Compression of the Import-Export Structure

The import structure of the model (the MPS/GE nest ms(i.s,r), detailed in box 7) and the export structure (the nest xs(i,s,r), detailed in box 8) need $4n^2m$ variables in a model with n regions and m tradable commodities, which for the 13-region, 17-commodity model used here, would need 11,492 variables- which would almost certainly render the model too large to be solved in levels form. Fortunately, the import and export structures of the model can be compressed to use fewer variables without any loss of detail in the model:

Firstly, the two production activities ms(i,s,r) and xs(i,s,r) can be incorporated into one activity. The xs(i.s,r) adds transport costs to the fob price of exports, creating imports at cif prices. The activity ms(i.s.r) then adds the import tariff to the cif import price. Box 17 shows a new nesting structure for ms(i,s,r) that transforms exports at fob prices into imports at tariff-inclusive prices by performing both of these steps in one nest.

Box 17: Transport costs and import tariffs in one nesting structure

```
$PROD:ms(i,s,r) s:0
O:cifp(i,s,r) Q:VIWS(i,s,r)
I: gtp         Q:VTWR(i,s,r)
I:pd,s) Q:VXMD(i,s,r) P : (1 + TXO (i, s, r) ) A:Y(s) T:TX(i,s,r)
```

note: this nest replaces the previous ms(i,s,r) and xsd,s,r).

The second step of this compression procedure is to include this ms(i,s,r) nest inside the Armington import structure for the activity m(i,r) (the m(i.r) nest aggregates imports from different source regions in box 6), equating the output of the ms(i.s.r) activity (outputting good cifp(i,s.r)) with the input demand of activity m(i,r) for good cifp(i.s.r).

This is possible because of an undocumented feature of MPS/GE which allows a sub-nesting structure to be defined over a set. The MPS/GE nest for m(i,r) in box 18 has a two-stage nesting structure, with a top-level elasticity of SIGM(i). the Armington elasticity between goods from different regions of origin. and a series of lower-level nests. one for each member of the set s, with an elasticity of zero. The subscript ".TL" on the nesting elasticity line means "Text Label" in GAMS. The signifier "#(s)" following the declaration for the global trading price input gtp means that a separate demand for gtp is generated for each element of the set s, and since the last characters in the line are "s.TL:", they are placed in the nest for the corresponding element of set s.

Box 18: The full Import-Export relationship in one nesting structure

```
$FRCD:md,r)    s:SIGM(i)  s.TL:0
O:mp(i,r)      Q:VIM(i,r)
I:gtp#(s)      Q:VTWR(i,s,r)  P:(1+TMO(i,s,r))  A:Y(r)  T:TMd,s,r)  s.TL:
I:p(i,s)       Q:VXMD(i,s,r) P:((1+TMO(i,s,r))*(1+TXO(i,s,r)) s.TL:
+                             A:Y(s)  T:TXd,s,r)
+                             A:Y(r)  T:(TM(i,s,r) * (1+TX(i,s,r))

note: this nest replaces the previous m(i,r) nest (box 6).
      Also remove the ms(i,s,r) nest (box 17).
```

This formulation exposes some features of the GTAP model that are applicable in all the model's forms presented here (and to the real-world economy the model represents), but may not have been apparent earlier. Firstly, any tariff applies to transport services as well as the traded good, and must of course apply at the same rate. Secondly, any traded good may be taxed twice: first by an export tax accruing to the exporting region, and then by an import tariff. Also of note is that the size of the import tariff as a proportion of the exporter's market price p(i,s) depends on the export tax TX(i,s,r). This is because the import tax is an *ad valorem* tax after the export tax is applied; an increased export tax will increase the price of the good at the point where the import tariff is levied (the cif price), and for the same volume of trade will have the direct effect of increasing import tariff revenue.

Great care must be taken when making such changes to an MPS/GE structure, as there are many pitfalls (some undocumented) that could lead to the MPS/GE model representing a different economic interpretation to that which the modeller intends. One means of checking that the nest is correct is to calculate income and expenditure values in the benchmark, ensuring that they are equal.

Income for this nest in the benchmark is VIM(i,r), as this is the benchmark quantity of the nest's only output, mp(i,r), which has a benchmark price of unity, and is not taxed. The value that users expend indirectly on transport services is VTWR(i,s,r)*(1+TM0(i,s,r)) for each source region s. The value that users expend on goods is VXMD(i,s,r)*(1+TM0(i,s,r))*(1+TX0(i,s,r)). To check the total of these values, recall from Chapter 4 the following database relationships:

```
TX0(i,s,r)      = VXWD(i,s, r)/VXMD(i,s,r) - 1
VTWR(i,s,r)     = VIWS(i,s,r) - VXWD(i,s,r)
TM0(i,s,r)      = VIMS(i,s,r)/VIWS(i,s,r) - 1
VIM(i,r)        = sum[s,  VIMS(i,s,r)]
```

Then the expenditure on imports, is:

```
          sum[s,                VTWR(i,s,r)*(1+TMO(i,s,r))
                      +VXMD(i,s,r)*(1+TMO(i,s,r))*(1+TX0(i,3,r))
        = sum[s,  [VIWS(i,s,r) -
VXWD(i,s,r)]*VIMS(i,s,r)/VIWS(i,s,r)
                           +VXMD(i,s,r)*(VIMS(i,s,r)/VIWS(i,s,r))

        *(VXWS(i,s,r)/VXMD(i,s,r))]
        = sum[s, VIMS(i,s,r) -
VXWD(i,s,r)*VIMS(i,s,r)/VIWS(i,s,r)
                           +VXWS(i,s,r)*VIMS(i,s,r)/VIWS(i,s,r)]
        = sum[s, VIMS(i,s,r)]
        = VIM(i,r)
```

Which is identical to the income earned by the m(i,r) agent, as shown above.

5.2.4 Compression of the production and value-added nests

The model presented in section 5.1.2 has separate nesting structures for production and value-added, but this creates unnecessary variables for the composite value-added quantity va(j,r) and the composite value-added price pva(j,r). Production can be handled using fewer variables in the two-stage MPS/GE production function shown in box 18.

Box **18:** Two-Stage **Production**

```
$PROD:q(j,r)        s:0       va:SIGV(j)
O:py(j,r)         Q:VOM(j,r)        A:y(r)  T:TO(j,r)     P:(1-TOO(j,r))
I:ap(i,j,r)       Q:VFM(i,j,r)      A:y(r)  T:TF(i,j,r)   P:(1+TFO(i,j,r))
I:w(f,r)          Q:EVFA(f,j,r)       va:

note: this function combines the previous q(j,r) and va(j,r) nests
(boxes 1 and 2).
```

5.2.5 Other changes from the "standard" model

While the model presented in section 5.1.2 fully depicts the standard implementation of the GTAP model in Hertel *et al.*(1997),except for the changes to the structure of private preferences, there are some additional parameters included in the standard model that are not used for the purposes of the Uruguay Round analysis conducted in chapter 7.

Technical change parameters

The standard GTAP model includes various parameters to enable the modelling of technical change that are not included here. These include production shift parameters, factor-specific technical parameters and trade efficiency parameters.

Dummy tax parameters

Dummy tax parameters are included in the standard GTAP model to enable the imposition of certain taxes, such as factor taxes and uniform tariffs. The GTAP board intend some of these taxes to be used in future releases of the database, and the taxes are included in part to lay down the modelling framework prior to the base data being available. These taxes are not included here.

5.2.6 The modified GTAP model

Table 5-2 contains the full MPS/GE listing for the modified model, incorporating all of the changes to the model of section 5.1.3 discussed in sections 5.2.1 to 5.2.4. This model has 19 equations that are defined over sets such that for a model with n regions and m tradable commodities, $4+12n+6nm$ variables are required. For the aggregation size used here, where $n=13$ and $m=17$, there are 1,486 variables. The model presented earlier in section 5.1.2 uses $4+13n+12nm+2nm^2+4n^2m$ variables, or 21,831 variables. The effect that this reduction in model size will have on computing time and the feasibility of the modelling effort can be seen by calculating the size of the Hessian matrix which the non-linear solver must calculate at each step, and is the largest use of computing resources in the solution process. The Hessian matrix has a column for each variable and a row for each equation, expanded by sets. The model of section 5.1.2 must therefore have a Hessian matrix of 21,831 columns and 21,831 rows, with each point in the matrix taking up 8 bytes of computer memory (GAMS uses 8-byte double precision real numbers to store all variables and parameters). The memory used for such a matrix is 545Mb, which is more than large enough to make the problem unsolvable. The modified model, however, has 1,486 columns and 1,486 rows in its Hessian matrix, which will require 16.8 Mb of memory, making the problem solvable on a personal computer.

Table S-2 Modified MPS/GE model

```
$SECTORS:
        q(j,r)              ! Output
        ad, r)              ! Armington output
        gu(r)               ! Government Utility
        pu(r)               ! Private Utility
        gt                  ! Global Transport
        gs                  ! Global Savings
        wel(r)              ! Regional Welfare
        m(i,r)              ! Composite imports
$COMMODITIES:
        p(j,r)              ! Price
        w(f,r)              ! Wage
        ap(i,r )            ! Armington Price
        gp(r)               ! Government Price Index
        PP(r)               ! Private Price Index
        gtp                 ! Global Transport Price
        gsp                 ! Global Savings Price
        wpi(r)              ! Welfare Price Index
        mp(i,r )            ! Composite import price
SCONSUMERS
        y(r)                ! Income

$PROD:q(j,r)    s:0     va :SIGV(j)
O:p(j,r)      Q:VOM(j,r)       A:y(r) T:TO(j,r)    P: (1-TOO(j,r))
I:ap(i,j,r)   Q:VFM(i,j,r)     A:y(r) T:TF(i,j,r) P: (1+TFO(i,j,r))
I:w(f,r)      Q:EVFA(f,j,r)      va:

$PR0D:a(i,r)   s:SIGD(i)
0:ap(i,r),     Q:VAA(i,r)
I:p(i,r)       Q:VDA(i,r)
I:mp(i,r)      Q:VIA(i,r)

$PROD:m(i,r)   s:SIGM(i)  s.TL:0
O:mp(i,r)      Q:VIM(i,r)
I:gtp#(s)      Q:VTWR(i,s,r) P: (1+TMO (i,s, r) )  A:Y(r)  T:T.Md,s,r)  s.TL:
I:p(i,s)       Q:VXMD(i,s,r) P:((1+TM0(i,s,r)) *  (1+TX0(i,s,r)) s.TL:
+                            A:Y(s)  T:TX(i,s,r)
+                            A:Y(r)  T:(TM(i,s,r)  *  (l+TX(i,s,r))
```

```
$PROD:gu(r)         s:l
0: gp(r)            Q:(sumd,  VGA(i,r)) )
I:ap(i,r)           Q:VGM(i,r)     P:(1+TGO(i,r))    A:Y(r)  T:TG(i,r)

$PROD:pu(r)         s:l
0:cp(r)             Q: (sumd,  VPAd, r)) )
I:ap(i,r)           Q:VPM(i,r)     P: (1+TPO(i,r))   A:Y(r)  T:?:  i,r)

$PROD:gt              s:0
0:gtp               Q:(sum((i,r) , VST(i,r)) )
I:p(i,r)            Q:VST(i,r)


$PROD:gs              s:l
0:gsp               Q: (sum(r,SAVE(r)))
I:p("cgds",r)  Q: ((VOM("cgds",r)-VDEP(r)) )

SPROD: wel(r)        , s:1
O:wpi(r)            Q: (sumd,  VGA(i,r)  +  VPA(i,r))  +  SAVE(r))
I:gp(r)             Q: (sumd,  VGA(i,r)))
I:pp(r)             Q:(sum(i, VPA(i,r)) )
I:gsp               0:SAVE(r)

$DEMAND:y(r)        s:1
E:w(f,r)            Q: (sum[j, EVFA(f,j, r) ])
E:p("cgds",r) Q:(-VDEP(r))
D:wpi(r)            Q:(INCOME(r)-VDEP(r))
```

5.3 EXTENSIONS TO THE MODEL

Several extensions are made to the model developed in sections 5.1 and 5.2. With the emphasis here on a study of the Agricultural sectors in the Uruguay Round, section 5.3.1 expands the model to include a degree of factor immobility in agriculture. Sections 5.3.2 and 5.3.3 develop a means of modelling the particular policy constraints that the Uruguay Round sets on agricultural output and export subsidies, and section 5.3.4 introduces modelling of set-aside reforms, introduced as a reform to the EU's Common Agricultural Policy at around the same time as the Uruguay Round reforms. Section 0 extends the model to include imperfectly competitive industries with internal economies of scale.

5.3.1 Factor Immobility in Agriculture

The assumptions of constant returns to scale and perfect factor mobility may be justified for long-term analysis in most sectors, but for agricultural sectors there is good reason to modify them. With constant returns to scale, supply is perfectly elastic, with price determined purely by input costs. In partial equilibrium analysis input costs are treated as exogenous, but in **a** general equilibrium context they are endogenous, as in order to increase output firms must hire more factors and use more intermediate inputs. The increase in demand for factors will bid up factor wages. and intermediate input prices will also rise, partly in response to the original factor wage changes, and partly with demand as the industries producing intermediate products must also increase their use of factors in order to increase output. The result is that sectors have upward-sloping supply curves even with constant returns to scale.

In the standard neo-classical model the response of a sector's output to an increase in the producers' price is determined by the curvature of the production possibilities frontier in the neighbourhood of the initial equilibrium. The tighter that curvature (the lower the elasticity of transformation between sectoral outputs), the smaller the increase in output induced by a given proportionate price increase; i.e. the lower the elasticity of supply. The curvature of the frontier will be stronger (the supply elasticity lower) the more different are the factor intensities across sectors, the lower the elasticities of substitution between factors, and the lower the mobility of some or all factors between sectors.

In one of the most simple general equilibrium models, that of the small open economy with all goods traded and homogeneous, the story ends there. An increase in the world price of one good will lead to an expansion of that sector and a contraction of the other sector(s) as factors are bid away to the expanding sector. In a large open economy, or in a small open economy with goods differentiated by country of origin, or economies with non-traded goods, interaction with the demand side of the economy will complicate the story. Nevertheless, the basic propositions about curvature of the production possibilities frontier are unchanged. In particular, reducing the mobility of some or all factors between sectors will increase curvature and reduce supply responsiveness to price changes.

The elasticity of supply in any sector is therefore in part determined by how 'large' that sector is[12] in factor markets and in household expenditure; a sector that employs high proportions of the supply of labour and capital will need larger increases in

[12] As a trivial example, consider a closed economy with two sectors, employing one factor. If Y and Z are the factor demands in each sector, which must sum to fixed factor supply, then in order to increase the use of the factor by y percent in the Y sector, the Z sector must reduce its demand in percentage terms by $z = y\, Y/Z$,

If the Y sector employs two-thirds of the factor, then $Y = 2Z$ and $z = 2y$,

If the Y sector employs one third of the factor, then $V = \frac{1}{2} Z$ and $z = \frac{1}{2} y$

wages (and prices) to "choke off the factor demand from other sectors than a sector that employs small proportions of the supply of factors. Elasticity of supply is therefore higher in small sectors (i.e. agriculture) than in large sectors (i.e. manufacturing and services). Several possible methods exist to decrease supply elasticity in agriculture - decreasing returns to scale could be used, imperfect factor mobility could be imposed, or a specific-factors model could be used. The approach used here is to incorporate specific-factors, which also addresses issues familiar in agricultural economics, where it is generally recognised that some farm factors are not mobile.

The specific-factors approach used here fixes half of the land, labour and capital in each agricultural sector[13] while the remainder are perfectly mobile. This makes supply less elastic, because in order to increase output, the agricultural sectors must make a large increase in their employment of the mobile factors as employment of fixed factors cannot change. This induces a larger impact on the mobile factor markets than would otherwise be the case, with higher wages needed to enable sectors to expand output.

Specific factors are introduced simply by creating new factors in each region. Each mobile factor (land, labour and capital) has half of its agricultural employment reassigned to the corresponding specific factor[14]. With three new factors for each of the five agricultural sectors in each region, this increases the number of factors from three per region to eighteen per region. All factors (specific or mobile) enter the same CES nest - there is no attempt to put them into a more complex nesting structure.

5.3.2 **Uruguay Round Agricultural Output Subsidy Constraints**

All tax instruments in the GTAP model are *ad valorem* tax rates, which may be positive or, for a subsidy, negative. Subsidies are rare within the database with the exception of agricultural sectors in certain regions where either output subsidies,

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[13] Note that this is done for each agricultural sector (or sub-sector), not for the agricultural "sector" as a whole.

[14] Ideally, the percentage of factors that are fixed would be derived from data, and could be proxied, for example, by the proportion of farm income earnt from on-farm activities. Lacking this data on a global scale, a 50% fixed-factor proportion is used here. Experiments (not reported here) that varied this percentage globally found that results were fairly linear in the percentage used,

export subsidies or both are commonplace. Most of the eighteen countries and six composite regions use agricultural omput subsidies, the only exceptions being Malaysia, the Philippines, Singapore. China, Hong Kong, Taiwan, and Argentina.

The use of *ad valorem* tax and subsidy rates is reasonably realistic for the modelling most taxes. but in the current analysis of the Uruguay Round is not appropriate for agricultural subsidies because of the restrictions that the Uruguay Round Agricultural Agreement imposes on their use. The Agricultural Agreement stipulates that output expenditures and quantities of subsidised products must be reduced according to certain minimum rates.

Expenditure on output subsidies must fall by 20% ($13\frac{1}{3}$% for LDCs) on a non-product-specific basis. To facilitate this, the *ad valorem* rate for each good is reduced by the same percentage until the expenditure condition for all goods is met.

Box 19 demonstrates how the agricultural output subsidy constraint is endogenised within the model. The constraint is an inequality, so the left hand side (actual subsidy expenditure) must be less than or equal to the right hand side (allowed subsidy expenditure)

Equation 19.2 shows the output quantity of each good in each region. The value of output is therefore equation 19.2 multiplied by the price, and the export subsidy

Box 19: The Agricultural Output Subsidy Constraint

Constraint (for each region r):

$$\sum_i q(i,r) \times VOM(i,r) \times p(i,r) \times \max[0, -TOO(i,r)] \times NTO(r) \le wpi(r) \times mto(r) \times \sum_i OSUB(i,r) \quad [19.1]$$

where output quantity is $q(i,r) \times VOM(i,r)$ [19.2]

the subsidy rate is $\max[0, -TOO(i,r)] \times NTO(r)$ [19.3]

New Variable:

NTO(r)	Endogenous output subsidy multiplier

New Parameters:

OSUB(i,r)	Base output subsidy expenditure $OSUB(i,r) = \max[0, VOA(agr,r) - VOM(agr,r)]$ for $i \in$ agricultural goods $OSUB(i,r) = 0$ for $i \in$ non-agricultural goods
mto(r)	Output expenditure target as a multiple of base output expenditure = 0.8 for $r \in$ developed regions = 0.8666 for $r \in$ developing regions

expenditure is the value of output multiplied by the subsidy rate.

The LHS of equation 19.1 is equal to the sum over all commodities of output subsidy expenditure.[15] The subsidy rate is equal to the base subsidy rate (TO0(i,r)) multiplied by a common endogenous output subsidy multiplier - so that all subsidies rates are scaled by the same factor in order to meet the constraint.

The RHS of equation 19.1 is equal to the allowed level of subsidy expenditure, given by the original subsidy expenditure in region r, OSUB(r), multiplied by a common target multiplier, mto(r). This multiplier is set by the Uruguay Round conditions; for developed regions, a 20% fall in subsidy expenditure implies that mto (r) = 0.8. while for developing regions, a 13'/, % fall in expenditure implies that mto (r)=0.8666. The allowed subsidy expenditure is multiplied by the aggregate welfare price index for that region, wpi(r), which implies that the expenditure reductions are in real terms, not nominal. The Uruguay Round Agricultural Agreement specifies that expenditures need only fall by the specified percentage in nominal terms over the implementation period. However, a nominal fall would not be implementable here because the CGE model only defines relative prices (the welfare price index of the EU is held at unity as the numeraire in the simulations in chapters 6). In order to make a nominal reduction possible in the model, a macroeconomic side to the model would have to be introduced that determined inflation in each region.[16] Very few CGE models attempt to incorporate inflation and, given the data limitations of parameterising such a model world-wide, it is considered to be beyond the scope of the current analysis.

The Agricultural Agreement specifies that the output subsidy commitments are to be implemented on a non-commodity-specific basis. A country therefore must reduce its expenditure on agricultural subsidies overall by a certain percentage. but there is no restriction on the choice that governments may make on which subsidies to reduce. Half of subsidies (by value) could be cut by double the required percentage and the other half not cut at all, for example, so long as the total expenditure cut meets the

---

[15] In the model, this summation is restricted to those agricultural sectors that have output subsidies in the base data.

[16] Chapter 7 develops an alternative approach to modelling nominal reductions,

required level. There is no way of predicting within a CGE model which commodities will have output expenditures cut and by what percemage, so the means of implementing the reduction that is used here is to cut the *ad valorem* subsidy rate by the same percentage in each sector.

5.3.3 Uruguay Round Agricultural Export Subsidy Constraints

The Agricultural Agreement requires restrictions on export subsidies similar to those on output subsidies, with a specified reduction in the expenditure on subsidy programmes. There are two key differences, however. Firstly, the export subsidy restrictions are commodity-specific, so that expenditure must be reduced by a given percentage for each commodity, whereas the output subsidy expenditure reduction commitments are not commodity-specific. Secondly, an additional restriction is imposed on export subsidy programmes whereby the volume of subsidised exports must also fall by a given percentage.

To impose this dual constraint mechanism, *ad valorem* export subsidy rates for agricultural and food-processing goods are made endogenous within the model, with the following two conditions being met:

- Expenditure on export subsidies is reduced by at least 36% (24% for LDCs),
- The volume of subsidised exports is reduced by at least 21%.

These conditions are implemented on a product-specific basis. They imply four possibilities for each good:

I. The expenditure condition may be binding, with a 36%(24%) fall in expenditure and a greater than 21 % fall in export volume;

II. The quantity commitment may be binding, with a 21% fall in export volume and a greater than 36% (24%) fall in export expenditure;

III. The quantity commitment may not be binding, with subsidy rates (and thus expenditure) reduced to zero;

IV. Both commitments may be met, with neither being binding, if the *ad valorem* rate does not need to be reduced to meet the commitments (the rate will not *rise* to meet the expenditure and quantity reductions).

Of these four possibilities, IV is very unlikely if exports are facing reduced tariffs abroad as this will tend to increase both export volume and subsidy expenditure. III may occur where the initial *ad valorem* subsidy rate is small, as a 100% reduction in a small subsidy is unlikely to lead to a 21% fall in subsidised exports. For most EU goods either of the first two possibilities may occur.

These export subsidy rules are implemented in the model by the two constraints shown in boxes 20 and 21. In each constraint, the actual value is on the LHS, which must be less than or equal to the target value on the RHS.

Box 20: The Agricultural Export Subsidy Expenditure Constraint

```
Constraint (for each i,r pair where i is agricultural or food and
                where subsidies exist in the base data):
Σs(x(i,r,s)×VXMD(i,r,s)×p(i,r,s)×max[0, -TX0(i,r,s)]×NTX(i,r)
                <= wpi(r)×metx(r)×sum[s, XSUB(i,r,s)]              [20.1]

New Variable:
NTX(i,r)          Endogenous export subsidy multiplier

New Parameters:
XSUB(i,r,s)       Base export subsidy expenditure on good i exported
                  from region r to region s
                  = max[0,VXMD(i,r,s) - VXWD(i,r,s)]
metx(i,r)         Multiplier for expenditure on export subsidies
                  =0.64    if r is a developed country or region
                  =0.76    if r is an LDC country or region
```

The expenditure constraint in box 20 is similar to the output expenditure constraint in box 19; a sum (in equation 20.1 over destination regions) of quantity (x(i.r,s)xVXMD(i.r,s)) times price (p(i,r,s)) times base subsidy rate (TX0(i,r.s)) times endogenous multiplier (NTX(i,r)) gives export subsidy expenditure. The target expenditure is again multiplied by the aggregate welfare price index wpi(r), so the constraint is modelled as a real expenditure condition.

Box 21 shows the export quantity constraint, equation 21.1, where the export quantity is less than or equal to a target quantity.[17]

Box 21: The Agricultural Export Subsidy Quantity Constraint

```
Constraint  (for each i,r pair where i is agricultural or food and
            where subsidies exist in the base data):
Σ x(i, r, s)xVXWD(i, r, s) <= mqtx(r)x Σs VXWD(i,r,s)            [21.1]

New Paramer:
mqtx(i,r)        Multiplier for the quantity restriction on export
                 subsidies
                 = 0.79
```

Only one of equations 20.1 and 21.1 will be binding in the solution, but we do not know *a priori* which it will be. As only one variable (ntx) is being added to the model for each sector, we can only add one constraint. The procedure adopted is to solve the model with the expenditure constraint enforced in each agricultural and food sector that has subsidies, check the export quantities, and then resolve the model with the quantity constraint enforced in regions and sectors where appropriate. Usually this results in both constraints being satisfied (either as a binding equality or as an inequality), but if not, the model is resolved as many times as is necessary to satisfy both equations.

Two additional parameters are introduced to facilitate this: METX_FLAG(i,r) is a flag (taking either the value 0 or 1) to signify (if equal to one) that the export expenditure constraint is to be satisfied, but not the quantity constraint. MQTX_FLAG(i,r) is a flag that signifies that the quantity constraint is to be satisfied.

Note that where a subsidy on a certain good must meet a restriction, the *ad valorem* rate is reduced by the same proportion for all destination regions where a subsidy already exists. In reality, the Agricultural Agreement provisions allow governments to vary the degree of cuts on export subsidies according to destination.

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17 Note that in equation 20.1 the quantity is x(i,r,s)xVXMD(i,r,s) while in equation 21.1 the quantity is x(i.r.s)xVXWD(i.r.s). This difference is because the subsidy rate TX is applied to domestic prices, while equation 21.1 effectively uses weights determined by world value shares, VXMD(i,r,s) (implying weights determined by domestic value shares) could be used in equation 21.1, but world price shares are more appropriate. Equations 8,4 and 8.5 of box 8 calculate export quantities using both VXMD(i,r,s) and VXWD(i,r,s), and this is possible because prices are normalised to zero at each stage.

5.3.4 Set-Aside

Set-aside is introduced in a similar way to specific factors. In order to enforce a certain (here 10%) cut in the land used in EU cereals sectors, the level of land used in these two sectors must first be controlled and then reduced. When these sectors employ sectorally mobile land this cannot be done, so all land used in these two sectors is designated as sector-specific, and then the endowment of those factors is cut.

5.3.5 Internal Economies of Scale and Imperfect Competition

Monopolistic competition is a form of market structure where there are many buyers and sellers, but where firms face downward-sloping demand curves. The downward-sloping demand curve for these firms comes as a result of product heterogeneity, either because different consumers have a demand for different varieties of a product (or for different characteristics) or a demand for variety itself While monopolistic competition can be modelled in many forms, the model here draws on that used by Harrison. Rutherford and Tarr (1995).

This model retains the Armington assumption that defines the way that goods are sold in the perfectly competitive model. introducing market-differentiating suppliers that sell at different prices to their domestic and to each of their foreign markets. Firms from each region in the multi-regional trade model produce products that are differentiated from each other, and the Armington structure ensures that they are also differentiated from products produced by firms in other regions.

Each of the n firms in a particular industry has the following profit function:-

MC1: Profit function $\pi_i = p_i q_i - C_i$

π_i = firm profit

p_i = the price of firm i output

q_i = the quantity of output

C_i = total cost.

Differentiating with respect to q_i gives the Cournot profit maximising condition:-

MC2: Profit maximising condition $\frac{\partial \pi_i}{\partial q_i} = \frac{\partial p_i}{\partial q_i} q_i + p_i - c_i = 0$

c_i = the constant marginal cost of production $\partial C_i / \partial q_i$.

Rearrangement gives as the net mark-up over marginal costs mk_i :-

MC3: Derived mark-up formula $mk_i = \frac{p_i - c_i}{p_i} = -\frac{\partial p_i}{\partial q_i}\frac{q_i}{p_i} = \left|\frac{1}{\varepsilon_i}\right|$

which states that the net mark-up will equal the negative (or absolute value as the elasticity itself will always be negative) of the inverse elasticity of demand for the firm's output.

Inverse elasticities of demand in CES nests

A CES nesting structure is used to characterise the differentiation of products from suppliers in the same region. The absolute size of the inverse elasticity of demand in any CES nest is given by:-

MC4: CES inverse elasticity of demand $\left|\frac{1}{\varepsilon_i}\right| = (1 + \Omega)\left[\beta_i\left(\left|\frac{1}{\varepsilon^*}\right| - \frac{1}{\sigma}\right) + \frac{1}{\sigma}\right]$

β_i = The share of expenditure that good i has within the nest.

$\left|\frac{1}{\varepsilon^*}\right|$ = The absolute size of the inverse elasticity of demand for the output of the CES nest.

σ = The elasticity of substitution between goods in the nest.

Ω = A conjectural variation term, describing how a supplier expects other suppliers to react to its own actions.

Inverse elasticities of demand in the Armington structure

The Armington nesting structure of exports and domestic demands gives rise to three different inverse-elasticity terms:

$\left|\frac{1}{\varepsilon_{i,r}^D}\right|$ the inverse elasticity of demand for domestic goods of good i in region r,

$\left|\frac{1}{\varepsilon^M_{i,r}}\right|$ the inverse elasticity of demand for imports of good i in region r,

$\left|\frac{1}{\varepsilon^{MM}_{i,r',r}}\right|$ the inverse elasticity of demand for imports of good i exported from region r' to region r.

Assuming zero conjectures in these nests, these terms are given from equation MC4 as:-

MC5: Domestic Elasticity $$\left|\frac{1}{\varepsilon^D_{i,r}}\right| = \delta_{i,r}\left(1-\frac{1}{\sigma^D_i}\right)+\frac{1}{\sigma^D_i}$$

$\delta_{i,r}$ = the share of expenditure for good i in region r that is spent on the domestic good.

σ^D_i = the elasticity of substitution between domestic and imported goods for good i.

MC5': Import Elasticity $$\left|\frac{1}{\varepsilon^M_{i,r}}\right| = \left(1-\delta_{i,r}\right)\left(1-\frac{1}{\sigma^D_i}\right)+\frac{1}{\sigma^D_i}$$

MC5'': Import Elasticity by source $$\left|\frac{1}{\varepsilon^{MM}_{i,r',r}}\right| = \alpha_{i,r',r}\left(\left|\frac{1}{\varepsilon^M_{i,r}}\right|-\frac{1}{\sigma^M_i}\right)+\frac{1}{\sigma^M_i}$$

$\alpha_{i,r',r}$ = the share of imports from region r' in total imports of good i in region r.

Equation MC5' can be substituted into equation MC5'' to give:-

MC6: Import Elasticity by source $$\left|\frac{1}{\varepsilon^{MM}_{i,r',r}}\right| = \alpha_{i,r',r}\left[\left(1-\delta_{i,r}\right)\left(1-\frac{1}{\sigma^D_i}\right)+\frac{1}{\sigma^D_i}-\frac{1}{\sigma^M_i}\right]+\frac{1}{\sigma^M_i}$$

Inverse elasticities of demand for firm output

The representation of firms in a CES nest is derived from equation MC4. where the share in output is always equal to $1/n$. The inverse elasticity for firm i in region r selling to the domestic market $\left|1/\varepsilon_{i,r}\right|$ and the inverse elasticity for firm i in region r selling to foreign market r' $\left|1/\varepsilon_{i,r,r'}\right|$ are derived separately:-

MC7: Domestic inverse elasticity $\left|\frac{1}{\varepsilon_{i,r}}\right| = (1+\Omega_{i,r})\left[\frac{1}{n}\left(\left|\frac{1}{\varepsilon^{D}_{i,r}}\right| - \frac{1}{\sigma_i^{DD}}\right) + \frac{1}{\sigma_i^{DD}}\right]$

MC8: Import inverse elasticity $\left|\frac{1}{\varepsilon_{i,r,r'}}\right| = (1+\Omega_{i,r})\left[\frac{1}{n}\left(\left|\frac{1}{\varepsilon^{M}_{i,r,r'}}\right| - \frac{1}{\sigma_i^{DD}}\right) + \frac{1}{\sigma_i^{DD}}\right]$

Substituting equation MC5 into equation MC7 gives the equation for domestic mark-up $dmk_{i,r}$:-

$$\text{MC9:}\quad dmk_{i,r} = \left|\frac{1}{\varepsilon_{i,r}}\right| = (1+\Omega_{i,r})\left[\frac{1}{n}\left(\delta_{i,r}\left(1-\frac{1}{\sigma_i^{D}}\right) + \frac{1}{\sigma_i^{D}} - \frac{1}{\sigma_i^{DD}}\right) + \frac{1}{\sigma_i^{DD}}\right]$$

Substituting equation MC6 into equation MC8 gives the equation for the inverse import elasticity:-

$$\text{MC10:}\left|\frac{1}{\varepsilon_{i,r,r'}}\right| = (1+\Omega_{i,r})\left\{\frac{1}{n}\left(a_{i,r,r'}\left[(1-\delta_{i,r'})\left(1-\frac{1}{\sigma_i^{D}}\right) + \frac{1}{\sigma_i^{D}} - \frac{1}{\sigma_i^{M}}\right] + \frac{1}{\sigma_i^{M}} - \frac{1}{\sigma_i^{DD}}\right) + \frac{1}{\sigma_i^{DD}}\right\}$$

Equations MC9 and MC10 differ from those used in Harrison *et al.* in two respects. Firstly, the conjectural variation term here is the same for all markets (domestic and exports to all regions) whereas Harrison *et al.* employ a different conjectural variation term for each market. The assumption here is that firms" expectations as to how their competitors (those producing in the same region) will react do not vary according to where the goods are destined. The second difference is that equation MC10 maintains that the elasticity of substitution between goods produced by firms in the same region σ_i^{DD} still applies if the goods are destined for export. Harrison *et al.* replace σ_i^{DD} with σ_i^{M} in equation MC10, and while this simplifies the algebra a little, there does not seem to be any strong reason to do so.

Trade taxes and transport prices

Equation MC10 gives the inverse elasticity of demand for imports, while exporting firms must use the inverse elasticity of demand for exports in their mark-up calculations. To calculate the inverse elasticity for exports, the equation for the import price $mp_{i,r,r'}$ is used:-

MCI I: Import Price

$$mp_{i,r,r'} = \tau_{i,r,r'}tp\left(1 + tm_{i,r,r'}\right) + \left(1 - \tau_{i,r,r'}\right)xp_{i,r,r'}\left(1 + tm_{i,r,r'}\right)\left(1 + tx_{i,r,r'}\right)$$

which can be arranged to give an expression for the export price:-

MC12: Export Price

$$xp_{i,r,r'} = \frac{mp_{i,r,r'} - \tau_{i,r,r'}tp\left(1 + tm_{i,r,r'}\right)}{\left(1 - \tau_{i,r,r'}\right)\left(1 + tm_{i,r,r'}\right)\left(1 + tx_{i,r,r'}\right)}$$

By differentiating with respect to *mp*. the elasticity of export price with respect to import prices can be derived:-

MC13: Export Elasticity adjustment

$$\frac{\partial xp_{i,r,r'}}{\partial mp_{i,r,r'}}\frac{mp_{i,r,r'}}{xp_{i,r,r'}} = \frac{\tau_{i,r,r'}tp}{\left(1 - \tau_{i,r,r'}\right)xp_{i,r,r'}\left(1 + tx_{i,r,r'}\right)} + 1$$

Equation MC13 can be used to obtain the inverse export elasticity by adjusting the inverse import elasticity, since:

MC14: Inverse Export Elasticity

$$\frac{\partial xp_{i,r,r'}}{\partial x_{i,r,r'}}\frac{x_{i,r,r'}}{xp_{i,r,r'}} = \frac{\partial xp_{i,r,r'}}{\partial mp_{i,r,r'}}\frac{mp_{i,r,r'}}{xp_{i,r,r'}} \times \frac{\partial mp_{i,r,r'}}{\partial m_{i,r,r'}}\frac{m_{i,r,r'}}{mp_{i,r,r'}} \times \frac{\partial m_{i,r,r'}}{\partial x_{i,r,r'}}\frac{x_{i,r,r'}}{m_{i,r,r'}}$$

where $x_{i,r,r'}$ and $m_{i,r,r'}$ are real quantities of exports and imports. The first term in equation MC14 is the mark-up adjustment in equation MC13. The second term is the inverse elasticity of demand for imports calculated in equation MClO. and the final term is unity because export and import quantities are equal.

The final equation for the export mark-up is then equation MC8, with the import elasticity by source (MC6) multiplied by the export elasticity adjustment (MC13) prior to substitution:

MC15:

$$xmk_{i,r,r'} = \left(1 + \Omega_{i,r}\right)\left\{\frac{1}{n}\left[\left[\begin{array}{l} \alpha_{i,r,r'}\left(\left(1 - \delta_{i,r}\right)\left(1 - \frac{1}{\sigma_i^D}\right) + \frac{1}{\sigma_i^D} - \frac{1}{\sigma_i^M}\right) \\ \times\left(\frac{\tau_{i,r,r'}tp}{\left(1 - \tau_{i,r,r'}\right)xp_{i,r,r'}\left(1 + tx_{i,r,r'}\right)} + 1\right) + \frac{1}{\sigma_i^M} \end{array}\right] - \frac{1}{\sigma_i^{DD}}\right] + \frac{1}{\sigma_i^{DD}}\right\}$$

Calibration Procedure and modelling issues

The model is calibrated using parameters for the number of firms and conjectural variations, giving base mark-ups $xmk0_{i,r,r'}$ and $dmk0_{i,r,r'}$. This differs from other approaches such as Harrison *et al.* (1995) and Harris (1984) in that the base mark-ups are not calibrated to a target value (or cost-disadvantage ratio). In the absence of reliable data to use for these parameters, the course taken here, of calibrating to the number of firms, gives greater intuitive feel as to the competitive structure of the industries.

The CGE model is augmented with equations MC9 and MC15 and solved. In the course of solving the model, all elasticities of substitution are held constant, and the terms $\Omega_{i,r}$, $\tau_{i,r,r'}$ and $tm_{i,r,r'}$ are also exogenous, although import tariffs in particular may be changed from their base values. The share terms $\delta_{i,r}$, $\alpha_{i,r,r'}$ and $dmk0_{i,r,r'}$ are endogenous, as are the prices *fp* and $xp_{i,r,r'}$. Export tax rates are usually exogenous but can be endogenous if there is a net subsidy that must comply with export expenditure programme reductions. The number of firms is endogenous, but in line with Harrison *et al.*, is made exogenous to the mark-up equations.

The Full Model

Tables 5-3 to 5-7 list the full MPS/GE model, being the modified model of Table 5-2 extended to include factor immobility in agriculture, explicit Uruguay Round constraints and monopolistic competition.

Table 5-3: The Full MPS/GE model - Definitions

```
$SECTORS:
        Q(j,r)                  ! Output
        A(i,r)                  ! Armington output
        GU(r)                   ! Government Utility
        PU(r)                   ! Private Utility
        GT                      ! Global Transport
        GS                      ! Global Savings
        WEL(r)                  ! Regional Welfare
        Md,r)                   ! Aggregate Imports
$COMMODITIES:
        P(j,r)                              ! Price
        W(f,r)$(sum[j,SME(f,j,r)])          ! Wage
        SSW(f,j,r)$SSE(f,j,r)               ! Sector Specific Wage
        AP(i,r)$VAM(i,r)                    ! Armington Price
        GP(r)                               ! Government Price Index
        PP(r)                               ! Private Price Index
        GTP                                 ! Global Transport Price
        GSP                                 ! Global Savings Price
        WPI(r)                              ! Welfare Price Inde::
        MP(i,r)                             ! Aggregate Import Price
SCONSUMERS
        Y(r)                    ! Net Tax Income
        NFI(r)                  ': Net Factor Income
        FC(i,r)$MC_FLAG(i,r)  ! Fixed costs for imperfect competition
$AUXILIARY:
        NEX(i,r)$NEX_FLAG(i,r)
        NQX(i,r)$NQX_FLAG(i,r)
        NEO(r)$(sum[i,NEO_FLAG(i,r)] and OSUBO(r))
        NMK(i,r, s)$(NMK_FLAG(i,r) and TX0(i,r,s) lt 0)
```

Table 5-4: The Full MPS/GE Model - Production

```
$PROD:Q(j,r)     s:0       VAT:SIGL(j)   VA(VAT):SIGV(j)
 O:P(j,r)   Q:VOM(j,r)  P:(VOA(j,r)/VOM(j,r))
+ "      A:Y(r)$(NEO_FLAG(j,r) eq 0) T:TO(j,r)$(NEO_FLAG(j,r) eq 0)
+        A:Y(r)$NEO_FLAG(j,r)          N:NEO(r)$NEO_FLAG(j,r)
+                                      M:TOO(j,r)$NEO_FLAG(j, r)
 I:W("Labour",r)$SMF("Labour",j,r)    Q:SMF("Labour",j,r)        VA:
+ '       A:Y{r)  T:TF("Labour",j,r)
 I:W("Capital",r)$SMF("Capital",j,r)  Q:SMF("Capital",j,r)       VA:
+         A:Y(r)  T:TF("Capital",j,r)
 I:W("Land",r)$SMF("Land", j,r)  Q: SMF ( "Land" , j , r)        VAT :
+ ' A:Y(r) T : TF ( "Land", j , r i
 I:SSW("Labour",j,r)$SSF("Labour",j,r)    Q:SSF("Labour",j,r)    VA:
+ '       A:Y(r)  T:TF("Labour",j,r)
 I:SSW("Capital",j,r)$SSF("Capital",j,r) Q:SSF("Capital",j,r)    VA:
+ "       A:Y(r)  T:TF("Capital",j,r)
 I:SSW("Land",j,r)$SSF("Land",j,r)    Q:SSF("Land",j,r)          VAT:
+ "       A:Y(r)   T:TF("Land",j,r)
 I:AP(i,r)  Q:VFIM(i,j,r)  P: (1+TIO(i,j,r))
+ '       A:Y(r)    T:TI(i,j,r)
$CONSTRAINT:NEO(r)$(sum[i,NEO_FLAG(i,r)] and OSUBO(r))
NEO(r)  *  sum[i,NEO_FLAG(i,r)* VOM (i, r)*(-TOO (i, r)) *Q (i, r) *P(i,r)]
     =G=  MEO(r)*WPI(r)*sum[i, NEO_FLAG (i, r) *VOM (i, r)*(-TOO(i,r)) ] ;

$DEMAND: FC (i, r) $MC_FLAG (i, r)
        D:P(i,r)

$CONSTRAINT:NMK(i,r,s)$(NMK_FLAG(i,r) and TXO(i,r,s) lt 0)
         MQX(i,r)  =G=  X(i,r,s);
```

Table 5-5: The Full MPS/GE Model - Armington nesting and Imports

```
$PROD:A(i,r)    s:SIGD(i)
 O:AP(i,r)  Q:VAM(i,r)
 I:Pd,r) Q: (VDM(i,r)/(l + DMKO(i,r) ) ) P : (1+ DMKO (i,r) )
+        A:FC(i,r)$MC_FLAG(i,r)     T:DMK(i,r)$MC_FLAG(i,r)
 I:MP(i,r)  Q:VIM(i,r)

$PROD:M(i,r)      s:SIGM(i)   S.TL:0
 O:MP(i,r)  Q:VIM(i,r)
 I:P(i,s)$VIWS(i,s,r)
+  Q: (VXMD(i,s,r)/(1+XMKO(i,s,r)) )
+  P:  (  (1+TXO(i,s,r)  ) *(1  +  TMO(i,s,r))*(1+XMKO(i,s,r)  )  )  s.TL:

*   Tax when no special export subsidy rules are applied:
+   A:Y(s)$(NEXS_FLAG(i,s,r)  + NQXS_FLAG(i,s, r)  eq  0)
+   T:(TX(i,s,r)*(1+XMK(i,s,r)))
+                  $(NEXS_FLAG(i,s,r)+NQXS_FLAG(i,s,r)eq 0)

*   Subsidy when export subsidy expenditure rule is applied:
+  A:Y(s)$NEXS_FLAG(i,s,r) N: NEX (i, s ) $NEXS_FLAG d, s, r)
+                   M: (TXO(i,s,r)*(1+XMK(i,s,r)))$NEXS_FLAG(i,S,r)

*   Subsidy when export subsidy quantity rule is applied:
+  A:Y(s)$NQXS_FLAG(i,s,r)  N:NQX(i,s)$NQXS_FLAG(i,s, r)
+                   M: (TXO(i,s,r) *  (1+XMK(i,s,r)))$NQXS_FLAG(i,s,r)

*   Import Tariff when no special subsidy rules are applied.:
+   A:Y(r)  T:(TM(i,s,r)*(1+TX(i,s,r))*(1+XMK(i,s,r)))
+                         $(NEXS_FLAG(i,s,r)  + NQXS_FLAG(i,s,r)  eq 0)

*   Exogenous part of the Tariff with either export subsidy rule:
+   A:Y(r)  T:(TM(i,s,r)*(1+XMK(i,s,r)))
+                         $(NEXS_FLAG(i,s,r) or NQXS_FLAG(i,s,r) )

*   Endogenous part of the Tariff when expenditure rule is applied:
+       N:NEX(i,s)$NEXS_FLAG(i,s,r)
+     M: (TXO(i,s,r)*TM(i,s,r)* (1+XMK(i,s,r)) )$NEXS_FLAG(i, s, r)

*    Endogenous part of the Tariff when quantitiy rule is applied:
+       N:NQX(i, s)$NQXS_FLAG(i,s,r)
+     M: (TXO(i,s,r)*TM(i,s,r)* (1+XMK(i,s,r)) )$NQXS_FLAG( i, s, r)

*   Endogenous monopolistic competition markup:
+   A:FC(i,s)$MC_FLAG(i,s)
+              T:XMK(i,s,r)$MC_FLAG(i,s)

I:GTP#(s)$(VIWS(i,s,r)-VXWD(i,s,r))                  s.TL:
+                   Q: (VIWS(i,s,r)-VXWD(i,s,r) )
+                   P:(1+TMO(i,s,r))
+                   A:Y(r)   T:TM(i,s,r)
```

Table 5-6: The Full MPS/GE Model - Export Constraints

```
* Endogenous export (expenditure) constraint:

$CONSTRAINT:NEX(i,r)$NEX_FLAG(i,r)
  XSUBSO(i,r) * WPI(r) * MEX(i,r) =G=
 sum[s$(TX0(i,r,s)lt0),NEX(i,r)*(-TX0(i,r,s))*P(i,r)*VXMD(i,r,s)
        *[(1+XMK(i,r,s)*NMK(i,r,s))/(1+XMK0(i,r,s))]
* now multiply by * QXS(i,r,s) ];
  * [M(i,s) * [MPd,s)*PMSO(i,r,s)/
        [(1+TM(i,r,s)) * [TSHR(i,r,s)"GTP
                  + (l-TSHR(i,r,s)) *
(1+XMK(i,r,s)*NMK(i,r,s))/(1+XMK0(i,r,s))
                  * (1+ NEX(i,r) * TX0(i,r,s)) * P(i,r)]
        ]]**SIGM(i)] ];


* Endogenous export (quantity) constraint:

$CONSTRAINT:NQX(i,r)$NQX_FLAG(i,r)
        sum[s$(TX0(i,r,s) lt 0),
• Variable QXS(i,r,s):-
   [M(i,s) * [MP(i,s)*PMSO(i,r,s)/
        [(l+TMd,r,s)) * [TSHR(i,r,s)*GTP
   + (l-TSHRd,r,s)) * (1+XMK(i,r,s)*NMK(i,r,s))/(1+XMK0(i,r,s))
   * [1+(NEX(i,r)+NQX(i,r)) * TX0(i,r,s)] *P(i,r)]
      ] ]**SIGM(i)]

        *VXWD(i,r,s) ]=G=
        MQX(i,r) * sum[s$(TX0(i,r,s) lt 0),VXWD(i,r,s)];
```

Table 5-7: The Full MPS/GE Model - Utility, Welfare, Income, Global Transport and Savings

```
$PROD:GU(r)        3:1
        0:GP(r)       Q: (sum(i, VGA(i,r)))
        I:AP(i,r)     Q:VGM(i,r)
+                     P: (1+TG0(i,r))
+                     A:Y(r)     T:TG(i,r)

$PROD:PU(r)        s:1
        0:PP(r)       Q: (sumd, VPA(i,r)))
        I:APd,r)      Q:VPM(i,r)
+                     P:(1+TP0(i,r))
+                     A:Y(r)     T:TP(i,r)

$PR0D:GT              s:1
        0:GTP         Q: (sum( d,r) ,VST(i,r) ) )
        I:P(i,r;)     Q:VST(i,r)

$PROD:GS              s:1
        0:GSP             Q:(sum(r,SAVE(r)))
        I:P("cgds",r)     Q:((VOM("cgds",r)-VDEP(r)))

$PR0D:WEL(r)          s:1
        0:WPI(r )         Q: (sumd, VGAd,r)  + VPAd,r))  + SAVE(r))
        I:GP(r)           Q: (sumd, VGA(i,r)))
        I:PP(r)           Q: (sumd, VPA(i,r)))
        I:GSP             Q:SAVE(r)

$DEMAND:NFI(r)        s:1
        E:W(f,r)$(sum[j,SME(f,j,r)])  Q:(sum[j,SME(f,j,r)])
        E:SSW(f,j,r)$SSE(f,j,r)   Q:SSE(f,j,r)
*        E:W("Capital",r)         Q:EVOA("Capital",r)    R:ECAP(r)
        E:P("cgds",r)             Q: (-VDEP(r))
*        E:P("cgds",r)            Q: (-VDEP(r))          R:ECAP(r)
*        E:P(j,r)                 Q:VOM(j,r)$(RTS(j,r) ne 1)
        D:WPI(r)

$DEMAND:Y(r)       s:1
        D:WPI(r)



$0FFTEXT
```

5.4 WELFARE DECOMPOSITION

If we only need to know the aggregate welfare change then the equivalent variation can be calculated as follows:

```
EV(r) =  WEL(r)          -   (INCOME(r)-VDEP(r))
      =  (wel(r) - 1)  ×   (INCOME(r)-VDEP(r))
```

We can decompose EV changes according to the source of welfare gain by tracing welfare to real income, and then decomposing the sources of real income. Equations 14.2 and 15.10 imply that

```
WEL(r) = Y(r) / wpi(r)
```

so that

```
EV(r) = Y(r) / wpi(r)  - (INCOME(r)-VDEP(r))
      = [Y(r) - (INCOME-VDEP(r))]/wpi(r)
      + [1/wpi(r) - 1] × (INCOME(r)-VDEP(r))
```

The first term in this expression is real income, while the second term is the effect that rising prices have on welfare (i.e. the consumer surplus).

Equation 14.1 can then be substituted for Y(r) to obtain EV as a function of income sources. For clarity, take the following income function:

```
Y(r) = Σf EVOA(f,r) x w(f,r)
       - VDEP(r) × p("cgds",r)
       + Σi TAXREV(i,r)
```

where TAXREV(i,r) is the net revenue from all tax instruments for good i in region r.

The base income is

```
(INCOME(r)-VDEP(r)) = [Σf EVOA(f,r)] - VDEP(r)
                     + Σi TAXREV0(i,r)
```

where tax revenues in the base are denoted TAXREVO. Then

```
EV(r) = Σf [EVOA(f,r) × w(f,r) - EVOA(f,r) ] /wpi(r)
        -  [VDEP(r)×p("cgds",r) - VDEP(r)] /wpi(r)
        + Σi [TAXREV(i,r) - TAXREV0(i,r)] /wpi(r)
        + [1/wpi(r) - 1] × (INCOME(r)-VDEP(r))
```

This expression can be decomposed into four terms; producer effect (PE), depreciation effect (EV_DEP), tax revenue effect (TR) and a consumer effect (CE).

```
EV(r) = PE + EV_DEF + TR + CE
PE(r) = Σf [(w(f,r)-1) × EVOA(f,r) ] /wpi(r)
EV_DEP(r) = [VDEP(r)×p("cgds",r) - VDEP(r)] /wpi(r)
```

$$TR(r) = \sum_i [TAXREV(i,r) - TAXREV0(i,r)] / wpi(r)$$
$$CE(r) = [1/wpi(r) - 1] \times (INCOME(r) - VDEP(r))$$

Decomposing the Producer Effect

The producer effect term can be decomposed by sector. Recall that

$$EVOA(f,r) = \sum_j E(f,j,r) \qquad [15.4]$$
$$E(f,j,r) = e(f,j,r) \times EVFA(f,j,r) \qquad [2.4]$$

Then

$$PE(r) = \sum_f [w(f,r) \times \sum_j e(f,j,r) \times EVFA(f,j,r) - EVFA(f,j,r)] / wpi(r)$$
$$= \sum_f \sum_j (w(f,r) \times e(f,j,r) - 1) \times EVFA(f,j,r) / wpi(r)$$

Defining EV_PE(i.r) to be the producer EV effect by sector, then

$$EV\_PE(i,r) = \sum_f (w(f,r) \times e(f,j,r) - 1) \times EVFA(f,j,r) / wpi(r)$$

Decomposing the Consumer Effect

As welfare is a Cobb-Douglas function of private and government consumption, and savings. and as private and government consumption are both Cobb-Douglas functions of consumption of individual goods, the welfare price index wpi(r) can be expressed as:

$$wpi(r) = gsp^{\alpha(r)} \prod_i ap(i)^{\delta(i,r)}$$
$$\text{where} \quad \alpha(r) + \sum_i \delta(i,r) = 1$$

It can then be shown that

$$CE(r) \approx (1/gsp^{\alpha(r)} - 1) \times (INCOME(r) - VDEP(r))$$
$$+ \sum_i (1/ap^{\delta(i,r)} - 1) \times (INCOME(r) - VDEP(r))$$

Note that this expression is a first-order approximation to the true expression. which includes terms for prices in all pairs of sectors. all triples of sectors. all quadruples of sectors. and so on.

The contribution of the consumer effect for good i to welfare in region r is therefore

$$EV\_CE(i,r) = (1/ap^{\delta(i,r)} - 1) \times (INCOME(r) - VDEP(r))$$

And a savings term EV_SAVE shows the effect of the global savings price on welfare in region r:

$$EV\_SAVE(r) = (1/gsp^{\alpha(r)} - 1) \times (INCOME(r) - VDEP(r))$$

A "joint" factor EV_JOINT sums the approximation errors in the consumer surplus decomposition:

$$EV\_JOINT(r) = CE(r) - EV\_SAVE(r) - \sum_i EV\_CE(i,r)$$

Decomposing Tax Revenue

Tax revenue can be decomposed by type of tax. and by the commodity on which the tax is levied. Tax revenue can be found from the tax terms in equation 14.1:

$$
\begin{aligned}
TAXREV(r) = \; & I_{,} \; TO(j,r) \times Q(j,r) \times p(j,r) \\
& + \Sigma_{i,j} \; TFD(i,j,r) \times FDD(i,j,r) \; x \; p(i,r) \\
& + \Sigma_{i,j} \; TFI(i,j,r) \times FDMd,j,r) \times mp.(i,r) \\
& + \Sigma_{i} \; TPD(i,r) \times PDD(i,r) \times p(i,r) \\
& + \Sigma_{i} \; TPI(i,r) \times PDM(i,r) \times mp(i,r) \\
& + \Sigma_{i} \; TGD(i,r) \times GDD(i,r) \times pd, r) \\
& + \Sigma_{i} \; TGI(i,r) \times GDM(i,r) \times mp(i,r) \\
& + \Sigma_{i,s} \; TM(i,s,r) \times DM(i,s,r) \times CIFPd,s,r) \\
& + \Sigma_{i,s} \; TX(i,r,s) \times DX(i,r,s) \times P(i,r)
\end{aligned}
$$

The base tax revenue is

$$
\begin{aligned}
TAXREV0(r) = \; & \Sigma_{j} \; TO0(j,r) \times VOM(j,r) \\
& + \Sigma_{i,j} \; TFDOd,j,r) \times VDFMd,j,r) \\
& + \Sigma_{i,j} \; TFI0(i,j,r) \times VIFMd,j,r) \\
& + \Sigma_{i} \; TPD0(i,r) \times VDPM(i,r) \\
& + \Sigma_{i} \; TPI0(i,r) \times VIPM(i,r) \\
& + \Sigma_{i} \; TGD0(i,r) \times VDGM(i,r) \\
& + \Sigma_{i} \; TGI0(i,r) \times VIGM(i,r) \\
& + \Sigma_{i,s} \; TM0(i,s,r) \times VIWS(i,s,r) \\
& + \Sigma_{i,s} \; TX0(i,r,s) \times VXMD(i,r,s)
\end{aligned}
$$

so that

$$
\begin{aligned}
TR(r) = \; & \Sigma_{i} \; [TO(j,r) \times Q(j,r) \times p(j,r) - TO0(j,r) \times VOM(j,r)] \, /wpi(r) \\
& + \Sigma_{i,j} \; [TFDd,j,r) x FDD(i,j,r) x p(i,r) - TFDO(i,j,r) x VDFM(i,j,r)] \\
& \qquad /wpi(r) \\
& + \Sigma_{i,j} \; [TFI(i,j,r) x FDM(i,j,r) x mp(i,r) - TFI0(i,j,r) \times VIFM(i,j,r)] \\
& \qquad /wpi(r) \\
& + \Sigma_{i} \; [TPD(i,r) x pDD(i,r) x \; p(i,r) - TPDO(i,r) x VDPMd,r)] \, /wpi(r) \\
& + \Sigma_{i} \; [TPI(i,r) \times PDM(i,r) \times mp(i,r) - TPI0(i,r) \times VIPM(i,r)] \, /wpi(r) \\
& + \Sigma_{i} \; [TGD(i,r) x GDD(i,r) x \; p(i,r) - TGD0(i,r) \times VDGM(i,r)] \, /wpi(r) \\
& + \Sigma_{i} \; [TGI(i,r) \times GDM(i,r) \times mp(i,r) - TGI0(i,r) \times VIGM(i,r)] \, /wpi(r) \\
& + Ii,s \; [TM(i,s,r) x DM(i,s,r) x CIFP(i,s,r) - \\
& \qquad TM0(i,s,r) \times VIWS(i,s,r)] \, /wpi(r) \\
& + \Sigma_{i,s} \; [TX(i,r,s) x DX(i,r,s) x p(i,r) - TXO(i,r,s) x VXMD(i,r,s)] \\
& \qquad /wpi(r)
\end{aligned}
$$

The contribution of tax revenue for good i to welfare in region r is therefore

$$
\begin{aligned}
EV\_TR(i,r) = \; & [TO(j,r) \times Q(j,r) \times p(j,r) - TOO(j,r) x VOM(j,r)] \, /wpi(r) \\
& + \Sigma_{j} \; [TFDd,j,r) x FDD(i,j,r) x p(i,r) - TFDO(i,j,r) x VDFM(i,j,r)] \\
& \qquad /wpi(r) \\
& + \Sigma_{j} \; [TFId,j,r) x FDM(i,j,r) \times mp(i,r) - TFIO(i,j,r) x VIFMd,j,r)] \\
& \qquad /wpi(r) \\
& + [TPD(i,r) x PDD(i,r) x \; p(i,r) - TPD0(i,r) \times VDPM(i,r)] \, /wpi(r) \\
& + [TPI(i,r) \times PDM(i,r) \times mp(i,r) - TPI0(i,r) x VIPM(i,r)] \, /wpi(r) \\
& + [TGD(i,r) \times GDD(i,r) \times p(i,r) - TGD0(i,r) \times VDGM(i,r)] \, /wpi(r) \\
& + [TGI(i,r) \times GDM(i,r) \times mp(i,r) - TGI0(i,r) \times VIGM(i,r)] \, /wpi(r) \\
& + I_{s} \; [TM(i,s,r) x DM(i,s,r) x CIFP(i,s,r) - TM0(i,s,r) \times VIWS(i,s,r)] \\
& \qquad /wpi(r) \\
& + \Sigma_{s} \; [TX(i,r,s) \times DX(i,r,s) \times p(i,r) - TXO(i,r,s) x VXMDd,r,s)] \\
& \qquad /wpi(r)
\end{aligned}
$$

Interpreting the Welfare Decomposition

Chapters 6 and 8 will use this decomposition of welfare to interpret simulation results. There are two points that are made here to clarify the use of welfare decomposition techniques.

The Sources and Causes of Welfare Change

Welfare decomposition identifies the sources of welfare change, so a positive producer surplus in the services sector means that real income has increased because the service sector is either employing more factors, or it is paying them a higher wage. This does not identify the *cause* of the welfare change, which is far harder to assess. If the only change that is made to policy variables for a simulation is a reduction in a single tariff then we can say that the reduction in that tariff *causes* the welfare changes measured by the simulation, and using welfare decomposition we can identify the *sources* of gain. In partial equilibrium the sources and causes must be the same sector, but in general equilibrium some of the sources of welfare changes will occur in different sectors.

In a simulation where many policy instruments are changed, welfare decomposition will show the *sources* of welfare change, but in order to measure the *causes* (how much does each policy change contribute to welfare), it would be necessary to conduct a separate simulation for each policy instrument that is changed. Even then, the welfare changes from each separate simulation would not add up to the welfare change in the simulation with all policy instruments changed simultaneously because there is interaction between policy instruments. Chapter 6 looks for the causes of welfare change on a broad scale: with a large global model it is infeasible to run a separate simulation for every tariff and tax that is changed in the Uruguay Round reforms, but it is possible to separate the reforms into broad categories such as agricultural reforms, abolition of the MFA, and industrial market access reforms.[18]

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[18] In the 13 region, 17 sector model used in Chapter 6 the MFA abolition accounts for the removal of Voluntary Export Levies on 42 bilateral routes. Industrial market access reforms involve tariff liberalisation on approximately 1000 individual tariffs, while agricultural reforms involve tariff liberalisation on approximately 1250 tariffs, export subsidy liberalisation on around 400 subsidies, and the reform of approximately 100 output subsidies. There are over 2500 individual policy instruments that are reformed in the complete Uruguay Round simulation.

Price Non-Homogeneity

The welfare decomposition is not 'price homogeneous' i.e. homogeneous of degree zero in prices, but welfare is. To explain this, recall the expression for EV:

```
EV(r) = Y(r) / wpi(r)   - (INCOME(r)-VDEP(r))
```

Here both income Y(r) and the aggregate price index wpi(r) are nominal values, so the EV calculation is 'price homogeneous". Multiplying all nominal values by the same proportion will not change EV(r).

The first step in decomposing EV was to create two terms: an income effect (this was later decomposed into producer surplus, depreciation, and tax revenue effects) and consumer surplus:

```
EV(r)            = [Y(r)  - (INCOME-VDEP(r) ) ]/wpi(r)
                 + [1/wpi(r)  - 1] × (INCOME(r)-VDEP(r))
```

It is immediately apparent that these two terms are not 'price homogeneous': proportional increases in Y(r) and wpi(r) will increase the first term and reduce the second term.

In chapter 6, the aggregate price index wpi(r) for the EU region is used as the numéraire, so that wpi("eu") = 1; there will therefore be no overall consumer surplus change for the EU, although there will be consumer surplus contributions from individual goods, summing to zero. For regions that experience a rise in aggregate prices (i.e. where the simulations result in wpi(r) > 1), consumer surplus must be negative, and the price changes will tend to increase producer surplus and tax revenue (although these may still fall). The opposite will occur in regions where aggregate prices fall.

No attempt to correct the price non-homogeneity is made[19] because (i) EV as a whole is price homogeneous, as are all parts of the model, and (ii) any corrections would necessarily mean that welfare decompositions are not comparable across regions.

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[19] It would be possible (but time consuming) to solve the simulation n times, where n is the number of regions in the model, changing only the numeraire in each simulation to be wpi(r) for each region in turn and record the welfare decomposition only for the numeraire region, As wpi(r)=1 for the numéraire region, there would be no aggregate price effect on the decomposition terms,

5.5 CONCLUSIONS

This chapter has examined the GTAP model in more detail than the graphical representation given in Chapter 3. Section 5.1 introduced the standard GTAP model as an MPS/GE model, covering both the behavioural conditions for each sector and consumer and the accounting equations for market clearing in goods and factors. Section 5.2 examined various changes to this structure that make the model more tractable in the MPS/GE framework, and Section 5.3 presented extensions to this model to incorporate a degree of factor specificity, explicit Uruguay Round constraints and monopolistic competition. Section 5.4 demonstrated a means of decomposing welfare using this model.

Chapter 6 will use this model to examine various aspects of the Uruguay Round, and a further modified model will be used in later chapters that takes advantage of the new release (version 4) GTAP database.

An equivalent (and preferable because less time consuming) method would be to divide all nominal values in the calculation of EV_PS, EV_TR, EV_CS, EV_DEP, EV_SAVE and EV_JOINT by wpi(r).

CHAPTER 6

RESULTS FROM THE URUGUAY ROUND SIMULATIONS[1]

6.1 INTRODUCTION

This chapter presents the results from CGE modelling simulations conducted with the GTAP-based model using the aggregation described in chapter 4 (section 4.6.2) and the model structure described in chapter 5 (after modifications). A range of issues will be examined, from the "traditional"" aspects of global CGE analysis - equivalent variation by region and by reform component, to less common approaches - decomposing welfare results by sector, for example, and to comparisons with other modelling structures. A limited number of sensitivity tests are performed.

This chapter is structured as follows: section 6.2 presents the main results from the simulation exercises, section 6.3 presents various welfare decompositions of the sources of gains, and section 6.4 examines simulations that are intended to show the causes of the gains. Section 6.5 investigates what effect various modelling assumptions and parameters have on the results. Section 6.6 presents the results of a model that includes monopolistic competition, and section 6.7 examines EU farmer welfare under all the scenarios presented in other sections. Section 6.8 concludes.

6.2 THE URUGUAY ROUND AND ITS MAIN COMPONENTS

The first set of experiments follows those reported in Blake *et al.* (1996) and other previous studies in estimating: (i) the consequences of the full UR reform package, and (ii) the impact in isolation of each of the Agricultural Agreement, the MFA reforms and the industrial market access provisions.

[1] Some of the results presented in this chapter are in a paper forthcoming in the Journal of Agricultural Economics.

Table 6-1: Regional welfare gains (EV in Sbn and as a percentage of 1992 income)

	Full Uruguay Round reforms		Agricultural Components		Textiles and clothing liberalisation		Industrial market access	
ANZ	1.04	(0,36)	0,96	(0,33)	0,20	(0,07)	-0.14	(-0,05)
CAN	1.57	(0,30)	1.03	(0,20)	1.55	(0,30)	-1.06	(-0.20)
USA	21.46	(0.41)	2,65	(0,05)	15,99	(0,30)	2.55	(0.05)
JPN	26.65	(0,84)	5,16	(0,16)	-1.02	(-0,03)	22,91	(0.72)
EU	24.86	(0,42)	11.37	(0.19)	11.52	(0,20)	1,63	(0.03)
SKT	2.50	(0,52)	3,93	(0,82)	-1.60	(-0,33)	0,35	(0.07)
SHK	-3.21	(-7.11)	0.01	(0,02)	-3,59	(-7,95)	0,36	(0.79)
EIT	-1.68	(-0,23)	-0,29	(-0,04)	-1.13	(-0,15)	-0.19	(-0.03)
BRA	1.57	(0,47)	0,70	(0.21)	0.04	(0.01)	1.04	(0.31)
OMI	-8,43	(-0,34)	0.18	(0,00)	-5.13	(-0.21)	-2.98	(-0,12)
SSA	-0,49	(-0,33)	0,00	(0,00)	-0.15	(-0.10)	-0,32	(-0,22)
CHN	6,13	(1,37)	0.11	(0,02)	5,46	(1,22)	0,60	(0.13)
OLI	6,22	(1,49)	0.15	(0,04)	6,12	(1,46)	0,08	(0.02)
OECD	75,58	(0,50)	21.17	(0,14)	28,24	(0,19)	25.89	(0.17)
non-OECD	2.61	(0,05)	4,79	(0,09)	0,02	(0,00)	-1.06	(-0.02)
Middle Income	-9,25	(-0,23)	4,53	(0,11)	-11.41	(-0,28)	-1,42	(-0.03)
Low Income	11.86	(1.17)	0,26	(0,03)	11.43	(1.13)	0,36	(0.04)
World	78,20	(0.39)	25,94	(0,13)	28,25	(0,14)	24,83	(0.12)

Table 6-1 shows the regional welfare effects, measured in terms of the equivalent variation (EV) from the full UR reforms and for three of the major components: agricultural reform, liberalisation in textiles and clothing trade, and improved market access. The estimated global gain from the full reforms is approximately US$ 78 bn.

The three largest developed 'countries", the USA, Japan and the EU, dominate the welfare gains, together accounting for $72.58 bn of the $78.20 bn total world gain. Japan benefits the most, the major source of its gains being from industrial market access reforms, with some gains from agricultural liberalisation. The USA benefits mainly from textiles and clothing liberalisation, while the EU's main gains come from both agricultural and textile liberalisation.

China and the "Other Low Income" (OLI) group make the largest gains in terms of percent of income, and in both cases the major source of gains is from MFA reform. Australia and New Zealand (ANZ), Brazil (BRA) and South Korea/Taiwan (SKT) all make moderate gains, mainly from agricultural liberalisation, while Canada (CAN) makes moderate agricultural and textiles gains but an industrial market access loss.

Singapore and Hong Kong (SHK) lose the most as a percentage of income, and this loss is entirely due to a large welfare loss from textile and clothing liberalisation, where their established market position has been protected by VERs on newer textile and clothing producers. Removal of these VERs opens up world competition and erodes the market share of the established exporters. Other losers are the Economies in Transition (EIT), the "Other Middle Income" (OMI) group and Sub-Saharan Africa (SSA). this, with the exception of the OMI's small gain from agricultural liberalisation, coming from small losses in all areas. The problem for these areas, and for Sub-Saharan Africa in particular (which does not perform any liberalisation itself and is also granted preferential access to developed markets under the Generalised System of Preferences), is that they make only small gains directly from tariff liberalisation while they lose through indirect trade-diversion effects as other exporters gain from larger tariff reductions. Losses from textile and clothing liberalisation further worsen the position of these groups.

Table 6-2 reports on results for the EU sectors, showing the percentage change in various indicators. Producer prices are net of all taxes and subsidies, while the consumer price is the aggregate price of domestically produced goods and imports. The percentage change in the price of goods used as intermediate products is the same as the percentage change in the consumer price (the Armington elasticities are the same regardless of how goods are used). Using input-output coefficients, it is then possible to determine what role intermediate input prices play in determining output prices: the meat sector for example uses 0.49 units of Livestock for each unit of output. Table 6-2 shows that the intermediate/consumer price of Livestock falls by 0.62%. This contributes 0.30% (0.62% × 0.49) to the 0.48% fall in the producer price of Meat (the residual fall of 0.18% reflects increases in the prices of other intermediate goods and increases in wages)

As would be expected, the Uruguay Round reforms will confront all agricultural sectors and most food sectors (with the exception of "Other Agricultural Products") with falling price and output, the major sector affected being Non-Grain Crops. Note that Non-Grain Crops and Milk Products are constrained by Uruguay Round export quantity commitments, that the small initial export subsidy in the Livestock sector is eradicated, and that all other sectors are constrained by export subsidy programme expenditure commitments. In all cases except Non-Grain Crops and Livestock, the change in the *ad valorem* subsidy rate is lower than the 36% cut usually implemented in models that do not specifically model the subsidy commitments.

Table 6-3 shows the outcome for export subsidies in all regions and sectors. There are three possible outcomes;[2] The subsidies can be either eliminated, quantity-constrained, or expenditure-constrained. In most cases (21 of the 29 subsidies) the subsidy is eliminated, in four cases the subsidy is expenditure-constrained, and in four cases the subsidy is quantity-constrained. Six of the eight sectors where subsidies are not eliminated are in the EU, with one sector (milk products) retaining subsidies in both the USA and Canada. In all the eight cases where subsidies are not eliminated, the initial *ad valorem* rate of the subsidy was high. In general the sectors with the highest initial *ad valorem* subsidies become constrained by the expenditure commitment, as for any percentage change in the *ad valorem* subsidy, reform in the higher-subsidy sectors will induce a larger change in cif price and therefore (generally) export quantity than sectors with lower subsidies. This does not hold for all cases, however: in the EU the milk products sector has a higher *ad valorem* subsidy than the meat products sector (although not a large difference) but milk export subsidies become quantity-constrained and those for meat expenditure-constrained.

[2] In fact, as discussed in Chapter 5. there is a fourth possible outcome: that the commitments will be met at the original *ad valorem* subsidy rate, requiring no reduction. This possibility does not occur in any sector.

Table 6-2: Percentage changes for various indicators in the EU (full Uruguay Round reforms)

	Producer Price	Consumer Price	Output	Exports	Imports	Value Added	Export Subsidy Expenditure	Export Subsidy *ad valorem* Rate	Output Subsidy Expenditure	Output Subsidy *ad valorem* Rate
Paddy Rice	[illegible]	7.50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-14.25
Wheat	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-1227	[illegible]	-14.25
Other Grains	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-897	[illegible]	-14.25
Non-Grain Crops	[illegible]	[illegible]	-7.11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-14.25
Livestock	[illegible]	[illegible]	-0.90	21.96	[illegible]	[illegible]	-100.0	[illegible]	[illegible]	-14.25
Processed Rice	-1.02	-3.24	[illegible]	[illegible]	[illegible]	-2.32				
Meat Products	-0.48	[illegible]	[illegible]	[illegible]	[illegible]	-0.29	[illegible]	[illegible]	[illegible]	-14.25
Milk Products	[illegible]	-0.99	[illegible]	[illegible]	[illegible]	-1.31	[illegible]	[illegible]		
Other Agricultural Products	[illegible]	[illegible]	[illegible]	16.71	[illegible]	1.50				
Other Primary Products	[illegible]	0.21	[illegible]	4.35	[illegible]	[illegible]				
Textiles	-2.19	-3.25	[illegible]	11.31	[illegible]	-1.42				
Wearing Apparel	-2.15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
Energy	[illegible]	0.34	-0.13	[illegible]	4.55	0.41				
Chemicals	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.09				
Other Machinery	[illegible]	[illegible]	[illegible]	[illegible]	10.19	-0.14				
Other Manufactures	[illegible]	[illegible]	0.90	[illegible]	5.19	1.40				
Services	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				

Table 6-3: Export Subsidy Outcomes

	Sector	Outcome	Base Value (Sbn)	Initial *ad valorem* equivalent (%)
ANZ	Non-Grain Crops	Eliminated	neg	neg
	Milk Products	Eliminated	0.12	0,05
CAN	Wheat	Eliminated	0,30	7.1
	Other Grains	Eliminated	0.11	15.1
	Non-Grain Crops	Eliminated	0,06	5,0
	Milk Products	Quantity-constrained	0.12	44.1
	Other Agricultural Products	Eliminated	0.01	0,2
USA	Paddy Rice	Eliminated	0,02	5,8
	Wheat	Eliminated	0,85	16.7
	Other Grains	Eliminated	0,08	1,3
	Non-Grain Crops	Eliminated	0,01	0,003
	Meat Products	Eliminated	0.07	1,5
	Milk Products	Quantity-constrained	0,21	34,1
EU	Paddy Rice	Expenditure-constrained	0,08	76,5
	Wheat	Expenditure-constrained	2.64	67,6
	Other Grains	Expenditure-constrained	1.89	70,7
	Non-Grain Crops	Quantity-constrained	1.33	23,3
	Livestock	Eliminated	0.01	0,7
	Meat Products	Expenditure-constrained	3.14	44,8
	Milk Products	Quantity-constrained	4,30	47,7
BRA	Other Grains	Eliminated	neg	3,8
	Non-Grain Crops	Eliminated	0,07	2,5
	Meat Products	Eliminated	0.01	0,9
	Milk Products	Eliminated	neg	1.7
	Other Agricultural Products	Eliminated	0.02	0,2
EIT	Livestock	Eliminated	neg	neg
	Meat Products	Eliminated	0.02	1.7
	Milk Products	Eliminated	0.04	9,2
OMI	Milk Products	Eliminated	neg	0,07

notes: neg = negligible value

6.3 DECOMPOSITION OF RESULTS: THE *SOURCES* OF WELFARE CHANGES

Table 6-4 and Table 6-5 show results from decompositions of welfare for the EU in the full Uruguay Round scenario. Table 6-4 gives the results for aggregate sectors. Table 6-5 those for each sector in the model. The first three columns show the welfare decomposition using the techniques discussed in Chapter 5. giving (net) tax revenue. consumer effect and producer effect in each sector. Note that the "Other" row refers to savings and joint effects (the interaction between consumer effects in different sectiors) and depreciation effects. The next two columns give the welfare effects of changes in export and import prices. The terms-of-trade column is the sum of these. "Domestic" effects are all those welfare effects that are not accounted for by terms-of-trade changes. Therefore the tax revenue plus consumer effect plus producer effect sum to the total column. as do the terms-of-trade and domestic columns. The three decomposed effects (TR. CE. PE) can be regarded as resulting from either terms-of-trade or domestic effects.

Examining the total welfare effects by sector (the final column) in Table 6-4. it is apparent that the textiles and clothing sector is the largest source *of* welfare gain. $14bn. of which $12.4bn accrues to consumers via lower prices. Agriculture and food together account for a $10.5bn welfare gain; for the food sectors there are welfare gains in each category (TR. CE and PE) while in agriculture there are large (net) tax revenue gains because of lower subsidy payments. but high losses to producers. It is apparent that the redistributional effect of agricultural reform is much higher than the overall welfare gain in these sectors. Table 6-5 shows that the redistribution takes place

Table 6-4: Decomposition of welfare for EU in the full Uruguay Round (Sbn)

	Tax Revenue	Consumer Effect	Producer Effect	Export Price	Import Pnce	Terms-of-Trade	Domestic	Total
Agriculture	16.766	1.51	-15.13	2.229	-1.696	0.537	2,619	3.156
Food	2.182	3.723	1.451	2.622	-0.825	1.794	5,568	7.363
Textiles and Clothing	1.121	12.416	0.52	-0.642	8.052	7,41	6,647	14.057
Manufactures and Services	-11.379	-12.626	28.638	1.049	-2.821	-1.773	6,405	4,632
Total	8.755	0.000	16.110	5.267	2,703	7,970	16,895	24,865

Table 6-5 Decomposition of welfare for EU in the full Uruguay Round ($bn) - by sector

Sector	Tax Revenue	Consumer Effect	Producer Effect	Export Price	Import Price	Terms-of-Trade	Domestic	Total
Paddy Rice	[illegible]	0.042	0.123	0.018	-0.049	-0.031	[illegible]	-0.071
Wheat	1.357	0.075	-0.925	0.936	-0.057	0.879	[illegible]	[illegible]
Other Grains	0.761	0.125	0.774	0.513	[illegible]	0.450	[illegible]	0.112
Non-Grain Crops	11.842	1.028	[illegible]	0.782	-1.309	-0.547	[illegible]	[illegible]
Livestock	[illegible]	[illegible]	[illegible]	[illegible]	-0.218	-0.214	[illegible]	[illegible]
Processed Rice	-0.011	0.093	[illegible]	[illegible]	-0.015	-0.017	[illegible]	0.089
Meat Products	0.821	[illegible]	0.196	[illegible]	-0.156	[illegible]	[illegible]	[illegible]
Milk Products	[illegible]	0.718	0.218	1.726	[illegible]	[illegible]	[illegible]	[illegible]
Other Agricultural Products	[illegible]	1.651	1.037	-0.115	-0.594	-0.709	[illegible]	[illegible]
Other Primary Products	-0.224	[illegible]	[illegible]	0.038	-0.378	[illegible]	[illegible]	0.463
Textiles	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.252	2.559	[illegible]
Wearing Apparel	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6.158	[illegible]	[illegible]
Energy	0.142	-0.725	[illegible]	[illegible]	0.000	0.027	0.966	0.992
Chemicals	[illegible]	0.629	[illegible]	-0.050	[illegible]	[illegible]	-1.247	-1.457
Other Machinery	-7.274	[illegible]	[illegible]	[illegible]	[illegible]	0.853	-4.091	[illegible]
Other Manufactures	[illegible]	0.095	[illegible]	[illegible]	-0.812	0.586	1.378	[illegible]
Services	0.953	-13.478	[illegible]	[illegible]	[illegible]	0.189	8.596	8.785
Other		-5.023	0.625	0	0	0	-4.343	-4.342
Total	8.755	[illegible]	16.110	5.267	2.703	7.970	16.895	[illegible]

Table 6-6: EU Base Data on Agricultural Protection

	Output Subsidy		Export Subsidy		Tariff
	Rate (%)	Expenditure ($bn)	Rate (%)	Expenditure ($bn)	Rate (%)
Paddy Rice	7,20	0.15	76,46	0,09	128.70
Wheat	6,30	2.29	67,56	2,64	51.20
Other Grains	2,50	0,79	70.66	1,89	67.60
Non-Grain Crops	71,00	65,94	23,32	1.33	58,50
Livestock	9.16	19.46	0,66	0,01	39,24
Processed Rice	*	*	*	*	128.70
Meat Products	0,20	0,36	44,79	3.14	56.10
Milk Products	*	*	47.75	4,30	132.90
Other Agricultural Products	*	*	*	*	10.84

Note: * = no net subsidy

largely in the non-grain crops, the sector with the highest initial production subsidies, as shown in Table 6-6.

Much of the welfare gains to the EU accrue to the services sector, in fact the gain in this sector is $^1/_3$ the total EU gain, despite the fact that there is no liberalisation taking place in services because of the absence of GTAP data. Welfare gains occur in the services sector because distortions that bias production away from services are liberalised. This underlines one of the strong points of CGE modelling: that the general equilibrium effects of reforms can be large, and are completely missed by other forms of analysis.

Welfare ***Decomposition for the*** *USA*

Table 6-8 shows the result of decomposing welfare changes for the USA. The format of the table is identical to Table 6-4. Note that the large overall consumer gain and the losses from tax revenue and producer effects are a result of the price non-homogeneity discussed in chapter 5. Table 6-7 shows the percentage change in the aggregate price in each region, from which it can be observed that the USA experiences a small aggregate price fall, which will in itself transfer income from producers to consumers. The export price, import price, terms-of-trade, domestic and total columns are price homogeneous, and show that the majority of the USA's welfare gains accrue in textiles and clothing. 50% of the gains accrue because of import prices (a welfare increase through import

Table 6-8: Decomposition of welfare for USA in the full Uruguay Round (Sbn)

	Tax Revenue	Consumer Effect	Producer Effect	Export Price	Import Price	Terms-of-Trade	Domestic	Total
Agriculture	4,893	-0,737	0,863	1,987	-0,485	1.488	3,502	4,998
Food	-0,118	-1.394	-0,325	0,297	-0,656	-0,365	-1.477	-1.839
Textiles and Clothing	3,215	17,052	-0,159	-0,108	9,386	9,278	10,83	20,108
Manufactures and Services	-15.293	21,867	-14,123	-2,785	-4,625	-7,409	-0.137	-7,547
Total	-7,385	35,781	-6,842	-0,574	3,593	3,018	18.44	21,459

price changes must mean that import prices in this sector have fallen). The benefits of textile and clothing liberalisation to the USA are $15.99 bn (Table 6-1). while Table 6-8 shows that the gains in the textile and clothing sectors from the full reforms are $20.108 bn. This implies that the textile and clothing sector must benefit significantly trom the other Uruguay Round reforms.

Welfare Decomposition for Japan

Japanese equivalent variation (from Table 6-1) is high compared to other regions - it is the largest in dollar terms. and the third largest in percentage terms. Table 6-9 decomposes Japanese welfare for the full Uruguay Round reforms. and shows that most of the welfare gains accrue through manufactures and services. and that the gain from export price rises in these sectors is almost half the total welfare gain. Note that Japanese prices (Table 6-7) rise. leading to consumer losses and producer gains. There

Table 6-7: Percentage change in aggregate price level

CAN	-0.687
USA	-0.676
JPN	1.889
CHN	4,040
BRA	0,437
SSA	**0,448**
EIT	0.071
ANZ	**0,608**
EU	0 **(numéraire)**
SKT	0.867
SHK	2,443
OMI	0,094
OLI	5,873

Table 6-9: Decomposition of welfare for Japan in the full Uruguay Round (Sbn)

	Tax Revenue	Consumer Effect	Producer Effect	Export Price	Import Price	Terms-of-Trade	Domestic	Total
Agriculture	-0.813	0,747	-5,845	0	-2.819	-2,823	-3,072	-5,897
Food	-0,065	3,369	2,683	-0,017	-0.849	-0,865	6,852	5,985
Textiles and Clothing	-0,167	-1.362	1,236	0.167	-0,326	-0.158	-0.136	-0,294
Manufactures and Services	4.614	-54.721	98,748	11.066	-1,845	9.221	39,419	48.641
Total	3,493	-58,729	83,501	11.21	-5,936	5,274	21.377	26,651

are also large losses from the three components of the EV decomposition not shown in the table - the effect of rising prices on depreciation payments, the effect of rising prices on savings, and the "Joint" consumer effects.[3]

Total Welfare Change by Sector

Table 6-10 shows the total welfare accruing to each sector in each region as a result of the full Uruguay Round simulation, and can be used to aid the interpretation of welfare results overall because, despite the fact that the sources and causes of welfare change differ, we can infer something about the causes of welfare change from the sources. This is useful because the sources of gain are available by sector.

The economies in transition (EIT) lose from the Uruguay Round as a whole, and Table 6-1 shows that this is caused by losses in all three main components of the reforms, but that textiles and clothing liberalisation is the most significant cause of welfare loss. Table 6-10 demonstrates that the losses to EIT accruing to the textile sector are the largest losses to this region, but by no means dominate the welfare results. There is evidence that much of the $1.13 bn welfare loss from textile and clothing liberalisation is borne by other sectors, as the total loss in the textile and clothing sectors is $0.495 bn. EIT agricultural sectors unambiguously gain from the Uruguay Round, but the losses in the food processing sectors outweigh these gains by $0.44 bn. The largest welfare losses in manufactures accrue to the other machinery and other manufactures sectors, with a small gain in the energy sector.

[3] These effects are included in the column totals but are not shown individually.

Table 6-10: Total Welfare Change, by Region and Sector in the full Uruguay Round ($bn)

Sector	ANZ	CAN	USA	JPN	EU	SKT	SHK	EIT	BRA	OMI	SSA	CHN	OTH
Paddy Rice	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.000	[illegible]	[illegible]	[illegible]	[illegible]	0.469	[illegible]
Wheat	[illegible]	[illegible]	1.487	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Other Grains	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Non-Grain Crops	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.547	[illegible]
Livestock	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Processed Rice	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Meat Products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Milk Products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Other Agricultural Products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-1.571
Other Primary Products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-1.279	[illegible]	[illegible]	[illegible]
Textiles	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Wearing Apparel	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-1.270	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-1.252
Energy	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Chemicals	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-1.921	[illegible]	[illegible]	[illegible]
Other Machinery	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Other Manufactures	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Services	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5.760	[illegible]	[illegible]	[illegible]
Other	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total	[illegible]	[illegible]	21.459	28.651	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

The largest welfare loss from the full Uruguay Round reforms is in Singapore and Hong Kong (SHK). a region that makes a large loss from textile and clothing liberalisation. but small gains from both the agricultural reforms and market access reforms. Table 6-10 shows that there are no welfare gains in any sector in this region.

Table 6-11 presents the welfare effect of terms-of-trade changes. by commodity and also in total for each region. The Singapore and Hong Kong terms-of-trade deteriorate in every good. with the total welfare effect of terms-of-trade deterioration exceeding the overall losses from the Uruguay Round scenario. The terms-of-trade deterioration that results from the fall in export price of the wearing apparel sector is over 4% of 1992 income. underlying the critical importance of the abolition of the MFA to this region.

In three of the four regions where welfare falls as a result of the Uruguay Round (SHK, EIT and OMI). the terms-of-trade effects cause this result, in that the welfare loss from terms-of-trade deterioration in these regions exceeds the overall welfare loss. Sub-Saharan Africa's loss of $0.487 bn is almost accounted for by a $0.438 bn terms-of-trade effect. implying that there must also be other (allocative inefficiency) sources for welfare loss in this region.

6.4 DECOMPOSITION OF RESULTS: THE *CA USES* OF WELFARE CHANGES

Table 6-12 shows the results for four experiments that examine the effects of the EU making its Uruguay Round liberalisation components in the absence of liberalisation elsewhere. The 'EU Agriculture Reforms' column shows the effects of the CAP reforms preceding/concurrent with the Uruguay Round reforms. while the 'EU MFA Reforms' column shows the effects of the elimination of VERs on exports to the EU.

Comparison with Table 6-1 shows that one third of the global gains from the Uruguay Round come from the EU reforms. The gains conferred on other regions from EU liberalisation totals $11.38 bn, while the gain to the EU from other regions' reforms is $8.34 bn. The EU's gains are dominated by gains from its own reforms. particularly in agriculture and textiles. The industrial market access reforms give the EU a small gain

Table 6-11: The Welfare Effect of Terms-of-Trade ($bn)

Sector	ANZ	CAN	[illegible]	JPN	EU	SKT	SHK	ST	SRA	SMI	SSA	CHN	OILI
Paddy Rice	0.000	0.000	[illegible]	[illegible]	-0.031	0.000	[illegible]	0.000	-0.01	-0.01	0.000	0.000	0.000
Wheat	0.124	0.550	1.09	-1.14	0.879	0.214	[illegible]	0.3	-0.07	-0.53	-0.13	-0.277	-0.194
Other Grains	[illegible]	0.09	0.440	-1.9	0.50	0.17	[illegible]	0.16	0.00	-0.25	-0.036	[illegible]	[illegible]
Non-Grain Crops	0.57	-0.03	0.092	-0.588	-0.547	0.43	-0.146	0.17	0.104	0.000	0.13	0.161	[illegible]
Livestock	0.17	0.00	[illegible]	-0.1	-0.21	[illegible]	[illegible]	0.21	0.000	-0.02	0.000	0.120	0.000
Processed Rice	0.000	0.000	0.000	0.00	-0.017	0.000	[illegible]	0.000	0.0	-0.032	-0.01	0.10	0.036
Meat Products	0.106	0.011	-0.012	0.35	0.85	-0.22	-0.2	-0.141	0.21	-0.288	-0.045	[illegible]	0.014
Milk Products	0.170	0.015	0.000	0.348	1.8	-0.08	-0.53	-0.079	-0.2	-0.739	-0.091	-0.01	-0.046
Other Agricultural Products	0.000	-0.053	-0.353	0.167	-0.709	-0.291	-0.324	-0.02	0.08	0.08	0.000	1.07	0.479
Other Primary Products	0.063	-0.069	-0.365	-1.31	-0.340	-0.181	-0.147	-0.041	0.000	0.278	0.02	-0.6	1.241
Textiles	0.020	0.103	0.532	0.079	1.252	0.35	-0.282	0.04	-0.052	-0.53	0.000	0.00	0.179
Wearing Apparel	-0.032	0.534	8.746	0.237	6.158	-1.0	-1.239	0.4	-0.0	-2.749	0.000	-1.22	1.546
Energy	0.000	-0.016	-0.1	-0.027	0.027	0.00	0.000	-0.01	0.000	-0.036	0.00	0.046	0.11
Chemicals	-0.05	-0.060	-0.412	0.39	-0.210	-0.071	-0.123	-0.0	0.000	0.318	-0.012	0.220	0.152
Other Machinery	-0.120	-0.08	-3.311	4.582	-0.853	0.232	-0.329	-0.071	-0.03	-1.457	-0.21	0.592	0.039
Other Manufactures	-0.18	-0.432	-2.196	3.528	-0.58	0.104	-0.847	-0.18	-0.01	-1.885	-0.151	1.098	0.55
Services	0.05	-0.0	-0.978	1.675	0.189	0.0	0.27	-0.19	0.000	-0.570	-0.096	0.50	0.56
Total	0.364	0.1	3.18	5.27	7.970	-2.82	-4.177	-1.725	-0.070	-9.0	-0.38	2.635	1.399

Table 6-12: Decomposition of regional welfare effects of EU reforms and main components (in Sbn and as a % of regional GDP)

	Full EU Reforms		EU Agriculture Reforms		EU MFA Reforms		EU Industrial Reforms	
ANZ	0,47	(0,16)	0,30	(0,10)	0,09	(0,03)	0,07	(0.02)
CAN	0.32	(0,06)	0,09	(0,02)	0,05	(0,00)	0.18	(0,03)
USA	-0,89	(-0,02)	0,08	(0,00)	-0,48	(0,00)	-0.51	(0,00)
JPN	7,88	(0,25)	-0,60	(-0,02)	-0.41	(-0,01)	8,90	(0,28)
EU	16,52	(0,28)	10.14	(0.17)	12.86	(0,22)	-6,98	(-0.12)
SKT	-0,16	(-0,03)	-0.10	(-0,02)	-0.38	(-0,08)	0,33	(0.07)
SHK	-1,44	(-3,20)	-0,10	(-0,22)	-1,45	(-3,21)	0,12	(0.26)
EIT	-0,84	(-0.11)	-0,16	(-0,02)	-1.05	(-0.14)	0,42	(0.06)
BRA	0,44	(0,13)	0,32	(0.10)	0,08	(0,02)	0,22	(0.07)
OMI	-0,20	(0,00)	0,71	(0,03)	-2,72	(-0.11)	1.96	(0.08)
SSA	3,54	(0,85)	0,06	(0,02)	3.17	(0,76)	0,26	(0.06)
CHN	2.15	(0,48)	0,04	(0,00)	1.78	(0.40)	0,31	(0.07)
OLI	0,10	(0,07)	0,12	(0,08)	-0,09	(-0,06)	0,08	(0.05)
OECD	24,3	(0.16)	10,01	(0,07)	12.11	(0,08)	1,66	(0.01)
non-OECD	3,59	(0.07)	0,89	(0,02)	-0,66	(-0,01)	3,7	(0.07)
Middle Income	-2,2	(-0.05)	0,67	(0,02)	-5,52	(-0.14)	3.05	(0.08)
Low Income	5.79	(0.57)	0,22	(0,02)	4,86	(0,48)	0.65	(0.06)
World	27.90	(0.14)	10,90	(0,05)	11.44	(0,06)	5.35	(0.03)

($1.63 bn) overall but a loss ($6.98 bn) from its own reforms. This is caused by a terms-of-trade deterioration in manufactured goods, and it is Japan that is the main beneficiary from EU industrial market access reforms.

Table 6-13 shows the results from four experiments that break down the effects of (world-wide) agricultural liberalisation into the four different classes of agricultural reform: tariff reform, export subsidy reform, output subsidy reform, and EU set-aside reform.

The EU, as the region where both export and output subsidies are largest, is the only region to make a large gain from their liberalisation, although the USA makes some gains from the liberalisation of its lower cost subsidy regime. In the EU, around two-thirds of the welfare gain from agricultural reform come from the subsidy reforms. Given that the EU's expenditure on output subsidies is much higher than its

Table 6-13: Decomposition of the Agricultural Reforms (in Sbn and as a % of regional GDP)

	Import Tariff Reforms		Export Subsidy Reforms		Output Subsidy Reforms		Set-Aside Reforms	
ANZ	0,42	(0.15)	0,30	(0,10)	0,15	(0,05)	0,00	(0,00)
CAN	0.34	(0,07)	0,39	(0,07)	0,23	(0,04)	0,00	(0,00)
USA	0.81	(0.02)	0,86	(0,02)	0,95	(0,02)	0,00	(0,00)
JPN	6.65	(0,21)	-1.06	(-0,03)	-0,06	(0,00)	-0,06	(0,00)
EU	3,56	(0,06)	4,52	(0,08)	2,80	(0,05)	-0.18	(0,00)
SKT	4,37	(0.91)	-0,27	(-0,06)	-0,13	(-0,03)	0,00	(0,00)
SHK	0,22	(0,48)	-0,09	(-0,21)	-0,10	(-0.22)	0,00	(0,00)
EIT	0,04	(0.00)	-0,41	(-0,06)	0.15	(0.02)	-0.01	(0,00)
BRA	0,68	(0.20)	0,06	(0,02)	0.15	(0,04)	0,09	(0.03)
OMI	1,50	(0.06)	-1,16	(-0,05)	0.17	(0,00)	0,00	(0.00)
SSA	0,17	(0.12)	-0,19	(-0,13)	0,05	(0,04)	0,00	(0.00)
CHN	0,15	(0,03)	-0,13	(-0,03)	0,09	(0.02)	0,00	(0.00)
OLI	0,22	(0,05)	-0,13	(-0,03)	0,07	(0.02)	0,00	(0.00)
OECD	11.78	(0,08)	5.01	(0,03)	4,07	(0.03)	-0,24	(-0.00)
non-OECD	7,35	(0,14)	-2,32	(-0.05)	0,45	(0.01)	0,08	(0.00)
Middle Income	6,81	(0,17)	-1,87	(-0.05)	0,24	(0,01)	0,08	(0.00)
Low Income	0,54	(0,05)	-0.45	(-0.04)	0,21	(0,02)	0	(0.00)
World	19,15	(0,09)	2,67	(0.01)	4,52	(0,02)	-0.17	(0,00)

expenditure on export subsidies (see table A1). the fact that the gains to the EU from export subsidy reform are much greater than the gains from output subsidy reform is an indication of how trade-distorting and welfare-reducing are export subsidies.[4]

For the world as a whole, tariff liberalisation is the most important feature of the agricultural reforms although, as would be expected, the USA and agricultural exporters such as Australia, New Zealand and Canada make significant gains from subsidy liberalisation. Food importing countries/regions such as Japan, South Korea and Taiwan (SKT) and the 'Other Middle Income' (OMI) group suffer significant

4 Even though export subsidies expenditure is reduced by at least 36% and output subsidy expenditure by 20%, it is obvious that given the total expenditure on subsidies from Table A1 that the total dollar expenditure on output subsidies is reduced by far more than for export subsidies

Table 6-14: Decomposition of regional welfare effects of differing assumptions (in $bn and as a % of regional GDP

	Standard GTAP Assumptions		Main Model with no Endogenous Subsidy Rates		Main Model with no Fixed Factors		Main Model	
ANZ	1.12	(0,38)	1.08	(0,37)	1,06	(0,36)	1.04	(0,36)
CAN	1.35	(0,26)	1.42	(0,27)	1,56	(0,30)	1.57	(0,30)
USA	20.96	(0,40)	20,76	(0,39)	21.66	(0.41)	21.46	(0,41)
JPN	30.51	(0,96)	27,17	(0,86)	29,65	(0,94)	26,65	(0,84)
EU	36,55	(0,62)	29,06	(0,50)	30.10	(0,51)	24,86	(0,42)
SKT	3,29	(0,68)	2,66	(0,55)	3.09	(0,64)	2,50	(0,52)
SHK	-3,22	(-7,12)	-3.21	(-7.11)	-3,21	(-7.11)	-3.21	(-7.11)
EIT	-1.78	(-0,24)	-1,92	(-0,26)	-1,42	(-0,19)	-1.68	(-0,23)
BRA	1.68	(0,50)	1.57	(0,47)	1.67	(0,50)	1.57	(0,47)
OMI	-8.02	(-0,33)	-8,47	(-0,34)	-7,89	(-0,32)	-8,43	(-0,34)
SSA	-0.77	(-0.52)	-0,56	(-0,38)	-0,64	(-0,43)	-0,49	(-0,33)
CHN	6.38	(1.43)	6.18	(1,38)	6,28	(1,40)	6.13	(1.37)
OLI	6.44	(1,54)	6,27	(1.50)	6,37	(1.52)	6,22	(1.49)
OECD	90.49	(0,60)	79,49	(0,53)	84.03	(0,56)	75,58	(0,50)
non-OECD	4	(0,08)	2,52	(0,05)	4,25	(0,08)	2.61	(0.05)
Middle Income	-8.05	(-0,20)	-9,37	(-0,23)	-7,76	(-0,19)	-9,25	(-0.23)
Low Income	12.05	(1.19)	11.89	(1.17)	12,01	(1.19)	11.86	(1.17)
World	94,48	(0,47)	82.01	(0.41)	88,30	(0,44)	78,20	(0.39)

losses from the subsidy reforms (particularly export subsidies) as the price that they pay for agricultural imports increases when the subsidies are reduced.

6.5 THE EFFECTS OF THE MODELLING ASSUMPTIONS

The effects of the modelling assumptions used in deriving all the results shown above are examined in Table 6-14. Each column represents the full Uruguay Round reform scenario, and the 'Main Model' column replicates earlier results for comparison. The 'Standard GTAP Assumptions" column removes all of the additional modelling features that are included in this paper but do not feature in most GTAP simulations, such as those employed by Harrison *et al.* (1995) and Francois *et al.* (1995). The other two columns each remove one model assumption from the 'Main Model".

Table 6 - 15: Percentage changes for EU sectors ('standard' model).

	Producer Price	Consumer Price	Output	Exports	Imports	Value Added	Export Subsidy Expenditure	Export Subsidy *ad valorem* Rate	Output Subsidy Expenditure	Output Subsidy *ad valorem* Rate
Paddy Rice	-1.26	-3.47	-14.88	-90.95	25.87	-18.26	-94.20	[illegible]	-31.85	-20.00
Wheat	-0.08	1.04	-12.55	-88.81	12.28	-13.78	89.52	[illegible]	-28.28	-20.00
Other Grains	-0.03	0.01	-110.8	-85.28	24.37	-11.97	-90.54	[illegible]	-28.53	-20.00
Non-Grain Crops	-0.76	1.08	-18.85	-35.50	29.32	-18.19	-55.32	[illegible]	-28.01	-20.00
Livestock	-0.77	0.85	-25.1	17.88	21.73	-4.18	-24.16	[illegible]	-21.37	-20.00
Processed Rice	-0.38	-2.63	-39.8	7.90	45.13	-3.70				
Meat Products	0.49	0.08	-26.5	-47.47	30.17	-2.35	-66.20	-36.00	-21.71	-20.00
Milk Products	0.48	0.02	-46.1	-44.18	57.37	-4.32	-64.09	-36.00		
Other Agricultural Products	0.30	0.17	-0.24	13.82	4.55	0.05				
Other Primary Products	0.18	0.19	0.87	5.73	[illegible]	0.97				
Textiles	-2.17	-32.2	-16.9	116.8	247.8	-1.42				
Wearing Apparel	-2.20	-12.82	-27.97	17.00	94.37	27.77				
Energy	0.24	0.20	-0.02	2.28	3.91	0.33				
Chemicals	0.17	-0.79	-0.41	7.51	8.12	-0.13				
Other Machinery	0.14	-1.34	-0.05	7.48	9.90	0.22				
Other Manufactures	0.01	-0.14	1.4	11.43	4.55	1.70				
Services	0.18	0.19	0.6	2.14	-0.23	0.92				

There is a clear difference between the results from the 'Standard' model and the one used here. The former 'overestimates' the global welfare gain by around 20%, and the EU gain by around 50%. in comparison with the latter. The 'Fixed Factors' assumption, modelling half of each agricultural factor as sectorally-specific, is the main source of difference, but it is clear that treating subsidy reductions purely as reductions in the *ad valorem* rates, with no account taken of the actual commitments, also overestimates welfare gains.

Table 6-15 shows the sectoral effects of the Uruguay Round in the 'Standard' model, and should be compared with Table 6-2. The 'Standard' model predicts large quantity changes and small price changes - a consequence of the highly elastic supply curves that are defined by the combination of constant returns to scale and perfect factor mobility. Examination of the columns for exports and export subsidy e.xpenditure makes it clear that the 'Standard' model incompletely represents the subsidy commitments entered into by Uruguay Round signatories.

The \ery elastic supply curves in the 'Standard' model pass virtually all price effects on to consumers, and result in large quantity shifts, while the *ad valorem* subsidy rates on both output subsidies and export subsidies are reduced by more than is necessary to meet Uruguay Round subsidy commitments.

Table 6-16 gives an indication of the sensitivity of the model to some of the elasticities that must be specified before the model can be calibrated. The Armington elasticities define the substitutability of imports and domestic products, and also the substitutability between imports from different regions. The \'alues for these elasticities are taken directly from the GTAP database. As Table 6-16 shows, the results are sensitive to these elasticities, with higher elasticities leading to much greater gains from liberalisation. In fact, the importance of the Armington elasticities outweighs the differences between standard and non-standard models structures.

Table 6-16: Decomposition of regional welfare effects for differing values of the Armington elasticities (in Sbn and as a % of regional GDP)

	Half Standard Values		Standard Values		Double Standard Values	
ANZ	0,71	(0,24)	1.04	(0.36)	1,81	(0,62)
CAN	0,69	(0.13)	1,57	(0,30)	3,90	(0,74)
USA	12,00	(0,23)	21,46	(0,41),	42,79	(0.81)
JPN	22,04	(0,70)	26,65	(0,84)	34.21	(1,08)
EU	19,88	(0,34)	24,86	(0,42)	41.33	(0,70)
SKT	0,58	(0.12)	2,50	(0,52)	6,56	(1,36)
SHK	-3,46	(-7,67)	-3,21	(-7.11)	-2,65	(-5,86)
EIT	-2,00	(-0,27)	-1,68	(-0,23)	-1.09	(-0.15)
BRA	0,78	(0,23)	1,57	(0,47)	3,57	(1.07)
OMI	-11,61	(-0,47)	-8,43	(-0,34)	-3,65	(-0,15)
SSA	-0.67	(-0,45)	-0,49	(-0,33)	-0,33	(-0,22)
CHN	2,37	(0,53)	6,13	(1,37)	10,02	(2,24)
OLI	1.97	(0,47)	6,22	(1,49)	1 1,00	(2,63)
OECD	55,32	(0,37)	75,58	(0,50)	124.04	(0,82)
non-OECD	-12,04	(-0,24)	2,61	(0,05)	23,43	(0,46)
Middle Income	-15.71	(-0,39)	-9,25	(-0,23)	2,74	(0,07)
Low Income	3,67	(0,36)	11.86	(1.17)	20,69	(2,04)
World	43,26	(0.21)	78.20	(0.39)	147,48	(0,73)

6.6 IMPERFECT COMPETITION

A variant of the model incorporates a version of monopolistic competition that models trade in differentiated products. The structure of the model follows the imperfectly competitive structure used in Harrison *et al.* (1995), with the exception that here we do not calibrate the model to predefined 'cost-disadvantage ratios'.[5] Each non-agricultural sector is modelled as monopolistically competitive, but perfect competition prevails in the agricultural sectors. Table 6-17 shows the welfare results for this model calibrated to four different initial numbers of firms per sector (in each region). In the absence of any data on the firm concentration ratio at the sector/region detail of the model, we examine how the number of firms affects the results.

[5] The conjectural variation is -0,5 in each sector so that each firm expects that for every two units by which it increases output, competitors will reduce their combined output by one unit.

Table 6-17: Welfare effects with monopolistic competition

	Perfect Competition		Monopolistic Competition							
			N= 10		N=5		N=3		N=2	
ANZ	1.04	(0,36)	1.17	(0,40)	1,27	(0,43)	1.42	(0,48)	1.61	(0,55)
CAN	1.57	(0,30)	1.74	(0,33)	1,89	(0,36)	2.10	(0,40)	2,38	(0,45)
USA	21.46	(0,41)	22.38	(0,43)	23.23	(0,44)	24,44	(0,46)	26,08	(0,50)
JPN	26.65	(0,84)	27.14	(0,86)	27.58	(0,87)	28,22	(0.89)	24,13	(0,92)
EC	24,86	(0.42)	26.08	(0,44)	27.22	(0.46)	28,85	(0,49)	31.06	(0,53)
SKT	2,50	(0.52)	2.64	(0,55)	2,76	(0,57)	2,94	(0,61)	3.19	(0.66)
SHK	-3.21	(-7.11)	-3,22	(-7.13)	-3,22	(-7.14)	-3,23	(-7.15)	-3,23	(-7.16)
EIT	-1.68	(-0.23)	-1.58	(-0,22)	-1,47	(-0,20)	-1.32	(-0,18)	-1.11	(-0.15)
BRA	1,57	(0,47)	1.72	(0,51)	1.86	(0,55)	2.07	(0,62)	2,36	(0.70)
OMI	-8,43	(-0.34)	-7.61	(-0,31)	-6,88	(-0.28)	-5,86	(-0,24)	-4,49	(-0.18)
SSA	-0,49	(-0,33)	-0,44	(-0,30)	-0,40	(-0.27)	-0,35	(-0,23)	-0,27	(-0.18)
CHN	6.13	(1.37)	6,08	(1,36)	6.04	(1.35)	5,99	(1.34)	5,94	(1.33)
OLI	6,22	(1,49)	6,31	(1.51)	6,40	(1.53)	6,54	(1,56)	6,75	(1.61)
OECD	75,58	(0,50)	78.51	(0,52)	81.19	(0.54)	85,03	(0,56)	90,26	(0,60)
non-OECD	2,61	(0,05)	3,9	(0,08)	5,09	(0.10)	6,78	(0,13)	9.14	(0,18)
Middle Income	-9,25	(-0,23)	-8,05	(-0,20)	-6.95	(-0.17)	-5,4	(-0.13)	-3,28	(-0,08)
Low Income	11.86	(1.17)	11.95	(1.18)	12,04	(1.19)	12.18	(1.20)	12.42	(1,23)
World	78,20	(0.39)	82,40	(0.41)	86,27	(0,43)	91.80	(0,45)	99,39	(0,49)

Table 6-17 demonstrates that the presence of monopolistic competition increases the returns to liberalisation, but that the increase is large only if we are prepared to accept very concentrated sectors. The effects on agricultural sectors (not shown here) are also small, partly because they are not modelled as monopolistically competitive, but also because the effects elsewhere, including the food processing sectors, are small.

6.7 EU FARM INCOME AND CAP COMPENSATION PAYMENTS

Table 6-18 shows the EU farm income effects of all the scenarios modelled above. Dollar value changes and percentage changes are given for the fixed and mobile agricultural factors separately, and together as the total farm income. In the full

Table 6-18: EU farm income* under all scenarios (Sbn and % change)

	Fixed		Mobile		Total	
Full Uruguay Round reforms	-14.26	(-11.65)	-9.01	(-7,60)	-23.26	(-9.66)
Agricultural Components	-14.67	(-11.99)	-9,43	(-7.96)	-24.10	(-10.01)
Textiles and clothing liberalisation	0.76	(0,63)	0.53	(0,44)	1.29	(0,54)
Industrial market access	0.01	(0.00)	0.09	(0,08)	0.10	(0.04)
Agricultural Import Tariff Reforms	-4.78	(-3.97)	-2.90	(-2.41)	-7.68	(-3.19)
Agricultural Export Subsidy Reforms	-3,83	(-3.18)	-2.34	(-1.95)	-6.18	(-2.56)
Agricultural Output Subsidy Reforms	-8.23	(-6.83)	-5.19	(-4.31)	-13.42	(-5,57)
Agricultural Set-Aside Reforms	0.37	(0.30)	-0.41	(-0.34)	-0.04	(-0.01)
Full EU Reforms	-15.02	(-12.27)	-9,49	(-8.01)	-24.51	(-10.18)
EU Agricultural Reforms	-15.57	(-12.73)	-9.96	(-8.41)	-2553	(-10.60)
EU Textile and Clothing Reforms	0.53	(0.44)	0.41	(0,34)	0.94	(0.39)
EU industrial Market Access Reforms	0.73	(0.61)	0,47	(0,39)	1.20	(0.50)
Standard GTAP Assumptions	-0,53	(-13.48)	-24,70	(-10.43)	-25.23	(-10.48)
No Endogenous Subsidy Rates	-19.77	(-16.15)	-12.08	(-10.20)	-31.85	(-13.22)
No Fixed factors	-0,03	(-0.71)	-17.59	(-7.43)	-17.62	(-7.32)
Halved Armington Elasticities	-11.62	(-9.49)	-7,37	(-6.22)	-18.98	(-7.88)
Doubled Armington Elasticities	-17.03	(-13.92)	-10.69	(-9.03)	-27,73	(-11.51)
Monopolistic Competition (N=10)	-14.23	(-11.63)	-8,98	(-7.58)	-23.21	(-9.64)
Monopolistic Competition (N=5)	-14.20	(-11.60)	-8.96	(-7.56)	-23,16	(-9.61)
Monopolistic Competition (N=3)	-14.16	(-11.57)	-8,92	(-7.53)	-23,08	(-9.58)
Monopolistic Competition (N=2)	-14.10	(-11.52)	-8,87	(-7.49)	-2297	(-9.54)

* Excluding compensation payments

Uruguay Round scenario, total farm income falls by $23,26 bn. of which $14,26 bn is a fall in the income of immobile factors.

Compensation payments are included in this model solely as a transfer payment from government to 'farm households'. The GTAP modelling framework employed here has a single household in each region that accounts for all private and government consumption and savings. As such, compensation payments are a transfer of income *within* this regional household. The results in table 10 are therefore for farm income *without* any compensation. The compensation payments are approximately $20 bn per year, which we assume will be paid to sector-specific agricultural factors, adding to the income of the fixed agricultural factors.

The results here show that, in net terms, the Uruguay Round will have a small, but positive, impact on fixed EU farm income after compensation, where the $20 bn compensation payments will more than offset the $14 bn loss prior to compensation, leading to a $6 bn gain.

As might be expected, the fall in agriculture-specific factor income is greater than the fall in payments to mobile factors in the sector,[6] and this fall in income comes mainly from the Agricultural Components of reform (and therefore mainly from reductions in output subsidies). The textile and clothing and industrial market access components increase farm income since liberalisation in other sectors increases the effective protection afforded to agriculture. Farm incomes are increased by $1.20 bn from EU industrial reforms, but only by $0.10 bn from global industrial reforms, indicating that the EU's own industrial tariffs afford negative protection to agriculture, while industrial tariffs abroad effectively protect EU agriculture.

The alternative assumption of monopolistic competition in the non-agricultural sectors has very little affect on farm income, largely because none of the agricultural sectors are directly effected by these scenarios and changes in other sectors (as seen in the small overall welfare changes) are small. Farm income does however show some sensitivity to the Armington elasticities, such that high elasticities, inducing greater trade shifts, lead to a larger farm income loss (farmers here gain $3 bn after compensation).

6.8 CONCLUSIONS

The main conclusions from the simulations conducted in this chapter is that the Uruguay Round reforms increase welfare for the world as a whole by $78.2 bn, or 0.39% of world GDP. These gains are, however, highly concentrated in the three main developed economies. While the three main elements of the Uruguay Round reforms, agriculture, textiles and clothing, and market access, each contribute around one third of this global gain, the agricultural and market access reforms lead to small losses in only a few regions while the textiles and clothing reforms involve major redistributional effects between developing countries. While agricultural tariff and output subsidy reforms improve welfare for almost all regions, export subsidy reforms also involve distributional effects that are larger than the overall welfare gains.

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6 Of the 7,6% fall in payments to mobile factors in agriculture, 6.5% comes from a fall in their employment.

Roughly half of the EU's welfare gains from the Uruguay Round come as a result of agricultural reforms, with most of the remainder coming from textile and clothing liberalisation. Of the agricultural reforms, the EU benefits the most from export subsidy liberalisation. Export subsidies are a very costly means of supporting farm income because of their highly distortionary nature. Farm incomes in the EU will rise by approximately $6 bn including compensation payments, but would fall considerably without compensation.

The USA benefits mainly from textile and clothing reforms, with large terms-of-trade effects in the clothing sector, while Japan's welfare gains are predominantly a result of industrial market access reforms. It is also worth noting that reform in the EU contributes substantially to gains in other regions.

As is often the case with CGE models, varying certain central assumptions in the model can have a substantial effect on the results. Thus there are notable differences between: (i) the 'Standard GTAP' and the 'Main' models, with the former suggests substantially larger gains; (ii) scenarios that assume different values of the Armington elasticities. Different assumptions about the (outward) mobility of a proportion of factors initially employed in the agricultural sectors has an appreciable effect on predictions of the impact of agricultural reform on 'farm incomes'. The assumption of imperfect competition does not greatly change results, although there are other forms ways of modelling imperfect competition (such as that performed in Francois *et al.* (1995)) that the literature suggests would give higher welfare gains.

CHAPTER 7

MODELLING THE URUGUAY ROUND COMMITMENTS, AGENDA 2000 AND CAP ABOLITION IN 2005

7.1 INTRODUCTION

This chapter develops the model introduced in Chapter 5 with various extensions designed to take advantage of the recent release of the version 4 GTAP database. This new database (released July 1998) is based in 1995, and includes a number of improvements over recent versions. The most significant of these are the expansion in the regional and commodity classification of the database, to 45 regions and 50 commodities. In particular, the EU, which has in previous versions of the database been a single region, is split into six regions - the UK, Germany, Denmark, Sweden. Finland, and the Rest of the EU. Although France. Italy and other major EU countries are included in one aggregate "Rest" region, this does represent an improvement for modellers concerned with EU policy.

The commodity classification of GTAP version 4 includes the expansion of the detail in the agriculture sector to 14 agricultural commodities, and 8 processed food commodities. This greatly increases the usefulness of the database for agricultural policy modelling. Three pairs of agricultural commodities and food products - Oilseeds and Vegetable Oils, Sugar cane/beet and Processed Sugar, and Raw Milk and Milk Products - provide explicit links between agricultural goods and processed food. The inclusion of certain products (Oilseeds, Milk, Sugar cane/beet) where particular CAP policies exist provides the opportunity for detailed modelling of the CAP. Therefore compensation payments and set-aside (Wheat, Other Grains and Oilseeds) can be modelled, and the relative impacts of reform on these three sectors can be assessed. Headage payments on cattle can be modelled, and milk and sugar production quotas can be modelled explicitly.

With these additions to the ability of this database to represent the CAP more accurately, this chapter extends the model of Chapter 5 to enable the modelling of three 'policy scenarios' for

2005: the incorporation of the commitments made in the Uruguay Round (UR) agreement, the further policy changes to be implemented under Agenda 2000, and the abolition of the CAP.

Table 7-1 shows how the 40 regions of the database are grouped into seven aggregate regions. There is some detail of the EU, with three EU regions, which will enable estimation of welfare impacts on each of these tliree regions separately. There is some obvious loss of detail in the modelling of the Cairns Group, LDCs and Rest of the World: these three regions contain 33 of the GTAP regions. The aggregation into the Cairns Group (agriculture and food exporters), LDCs (food importing LDCs), and) the Rest of the Worid (food-importing middle/high income countries does pay attention to the broad structure of agricultural trade in these regions.

Table 7-2 details the commodity aggregation, with the 50 GTAP regions aggregated into nine agricultural, six food products, and three other commodities. The detailed structure of agriculture and food in the GTAP version 4 database is retained as far as possible, although this means that there is inevitable lack of detail in the non-agriculture/food sectors.

7.2 PROJECTION TO 2005

With the modelling of Agenda 2000 in mind, and as the GTAP version 4 database is for 1995, this requires that this benchmark data be updated to 2005 by the use of projected growth in factor endowments and productivity over the intervening period. This updated data set, constructed using AGE modelling so that it is consistent with the constraints of general equilibrium, will be referred to as the *Base Case*, and is discussed first.

Table 7-1: Regional aggregation of the version 4 database used in this study

Aggregate Region	GTAP version 4 regions(s)
UK	UK
Germany	Germany
Rest of EU	Denmark, Sweden, Finland, Rest of the EU
USA	USA
Cairns Group	Australia, New Zealand, Indonesia, Malaysia, The Philippines, Thailand. Canada, Colombia, Argentina, Brazil, Chile, Uruguay
LDCs	China, Vietnam, India, Sri Lanka, Rest of South Asia, Mexico, Central America & Caribbean, Venezuela, Rest of Andean Pact, Rest of South America, Morocco, Rest of North Africa, South Africa, Rest of Southern Africa, Rest of Sub-Saharan Africa. Rest of the World
Rest of the World	Japan, South Korea, Singapore, Hong Kong, Taiwan, European Free Trade Area, Central European Associates, Former Soviet Union. Turkey. Rest of Middle East

Table **7-2: Commodity** aggregation of the version 4 database used in **this study**

Aggregate Commodity	**GTAP version 4 commodities**
Agricultural	
Wheat	Wheat
Other Grains	Other Grains
Vegetables and Fruit	Vegetables and Fruit
Oil Seeds	Oil Seeds
Sugar cane/beet	Sugar cane/beet
Raw Milk	Raw Milk
Other Agriculture	Paddy Rice, Plant-Based Fibres, Crops nec, Wool & Silk
Cattle, Sheep & Goats	Bovine Cattle, Sheep, Goats and Horses
Other Livestock	Animal Products nec
Food Products	
Cattle Meat	Bovine Cattle. Sheep. Goat. and Horse Meat Products
Other Meat	Meat Products nec
Vegetable Oils	Vegetable Oils
Milk & Milk Products	Milk& Milk Products
Sugar	Sugar
Other Food	Processed Rice, Beverages and Tobacco, Food Products nec
Other Commodities	
Other Primary	Forestry, Fishing, Coal, Oil, Gas. Minerals nec
Manufactures	Textiles. Wearing Apparel, Leather Products, Wood Products, Pulp Paper Products, Petroleum & Coal Products, Chemicals Rubber & Plastics, Mineral Products nec, Ferrous Metals, Non-Ferrous Metals, Fabricated Metal Products, Motor Vehicles & Parts, Transport Equipment, Electronic Equipment, Machinery and Equipment nec, Other Manufactures
Services	Electricity. Gas. Water. Construction, Trade & Transport Services. Other Private Services, Other Government Services, Dwellings

7.2.1 Linear **Expenditure** System (LES) for private demand

The CES preferences used in Chapter 5 do not lead to large inaccuracies when real income changes are small, but would greatly misrepresent the effects of the income increases that will occur when the model is projected to 2005. Therefore, LES preferences are used here in order to incorporate income elasticities (as supplied in the GTAP database) into the model.

7.2.2 Modelling Scenarios

The Umguay Round scenario is modelled as including all the Base Case factor productivity and productivity shocks, with the addition of tariff rate reductions and constraints on export subsidies and (for non-EU regions) output subsidies consistent with the UR agreements. Agenda 2000 reforms are implemented with the Uruguay Round reforms already in place. These reforms can be summarised as: reductions in intervention prices, changes to compensation and headage payments, changes in set-aside for arable crops, and increases in milk output quotas. **The** abolition of the CAP may not be on the policy agenda, but as a simulation it does provide an answer to how much the CAP costs the EU, in terms of CAP expenditure, farm income, and consumer welfare. All CAP instruments are fully removed.

7.2.3 Constructing the Base Case Data Set

The Base Case data set incorporates increases in factor endowments and productivity rates to model the structure of the worid economy in 2005. As is common with projected models of this type (e.g. Frandsen *et al.* 1998, Hertel *et al.* 1995 and 1996), factor endowment growth for each country/region (henceforth 'region') is included initially, and then projected regional GDP targets are set, and productivity rates adjusted so that GDP meets these targets. Typically this procedure produces low productivity growth rates, as most of the projected increase in GDP is met by factor endowment growth. For subsequent simulations, the non-agricultural productivity levels are set at the levels determined by the Base Case, and GDP in each region will be endogenous.

The numéraire used in the model is also increased to account for inflation between 1995 and 2005, giving (global) inflation at a rate of 2% per annum. It is not possible to model inflation in each region separately without greatly increasing the scope of the model and adding monetary sectors. Incorporating inflation does ha\'e advantages, because many of the instruments of interest are denominated in nominal terms (e.g. Uruguay Round expenditure constraints, intervention prices). As the database is dollar-denominated, the GDP price deflator in the USA is used as the numéraire, and is increased in the Base Case by the compounded rate of 21.9%, and then kept at that level for all other simulations. The 2% rate of inflation does not therefore represent a particular inflation rate in any country, but is a general world-wide price increase. No other prices are fixed, but as the model works in relative prices, average prices in other regions will increase at approximately the same rate.

Agricultural productivity rates are used to ensure that agricultural productivity growth is higher than in other sectors. This not only allows forecast productivity in agriculture to be used in **the** model, but is also necessary to ensure that agricultural prices do not rise unduly in the Base Case scenario. There are three principal determinants of prices in this scenario: the fact that agricultural factors become relatively more scarce will increase agricultural prices, low income elasticities **for** agricultural goods will lead to lower relative agricultural prices as incomes grow, and **higher** productivity growth in agriculture than elsewhere in the economy will lead to price decreases,

Table 7-3: Annual Growth Rates, 1995-2005

	Factor Accumulation			Real GDP	Productivity Growth	
	Unskilled Labour	Skilled Labour	Capital		Crops	Livestock
UK	-0.17	2,60	3.11	2,08	2.00	2,25
Germany	-0.17	2,60	3.11	2.08	2,00	2,25
Rest of EU	-0,17	2,60	3,11	2.08	2,00	2.25
USA	0,97	3.33	2,99	2.73	1.60	1.85
Cairns Group	1,77	4,10	5,05	5.03	1,98	2.20
LDCs	1,75	4,04	6,01	5.39	1.69	2.16
ROW	0,04	3,46	4,19	3.03	1.80	2.19

source: calculated from Frandsen. Jensen and Vanzetti (1998)

ceteris paribus. As a result, it is not possible *a priori* to say whether agricultural prices will rise or fall. but it would generally be accepted that prices will fall in real terms.

All the CAP instruments detailed below will remain at their 1995 levels for the Base Case scenario. but it is worth noting that output quotas will become more restrictive (i.e. the 'quota-free' output will rise), and market intervention may occur where prices fall below intervention prices.

7.2.4 Base case Growth Rates

Table 7-3 shows the annual growth rates imposed on the model for factor accumulation, GDP and agricultural productivity, based on those given by Frandsen *et al.*. Note that two other factors exist in the model: land and natural resources[1]. Neither factor undergoes growth between 1995 and 2005.

Frandsen *et al.* gives growth rates for a particular aggregation of the GTAP database; hence the EU regions are all given the same growth rates because Frandsen *et al.* has only one EU region. The USA growth rates correspond exactly to those in Frandsen *et ai,* but the growth rates for the other regions are aggregated according to factor endowments, GDP and agricultural output in the GTAP database as appropriate.

[1] Land is employed in all nine agricultural sectors; natural resources are employed only in the primary sector.

Table 7-4: CAP Instruments

	Uruguay Round	Agenda 2000	CAP Abolition
Import Tariffs (MT)	Uruguay Round liberalisation	Uruguay Round liberalisation	Uruguay Round liberalisation plus elimination of all agricultural and food tariffs
Export subsidies (VEL)	Variable export levies	Variable export levies	Elimination of all agricultural and food export levies
Market Intervention (MI)	Stock purchases to support market price at intervention price level	As baseline, but with intervention price reductions for some goods	Elimination of all market intervention
Set-aside (SA)	17.5% (commercial) set-aside, plus voluntary set-aside	Voluntary set-aside only	Elimination of all set-aside
Compensation Payments (AP)	Area payments based on reference base area	Reformed area payments	Elimination of all compensation payments
Compensatory Payments (CP)	Area payments for set-aside land	Reformed area payment	Elimination of all compensatory payments
Output Quotas (OQ)	Set quotas for output of raw milk and raw sugar	2% increase in milk quotas	Elimination of quotas
Headage Payments (HP)	Payment of premium for cattle based on number of cattle	Reformed premiums	Elimination of headage payments

7.3 MODELLING THE COMMON AGRICULTURAL POLICY

The CAP is modelled as consisting of eight instruments: import tariffs, export subsidies, market intervention, set-aside, compensation payments (arable area payments), compensatory payments (set-aside payments), output quotas and headage payments. Table 7-4 lists these CAP instruments, with a brief explanation of how these instruments are treated in the three scenarios to be modelled: a Uruguay Round scenario with full implementation of Uruguay Round reforms; an Agenda 2000 scenario, which will additionally include the proposed reforms to the CAP; and a CAP abolition scenario, which will show how the CAP shapes the EU and world economy.

Table 7-5 shows which CAP instruments are imposed on which sectors in the Base Case.

7.3.1 Import Tariffs

Table 7-6 shows the average tariff rates for the sectors used in the model, derived from those in the GTAP database. The GTAP database contains separate tariff rates for each *bilateral* trade

Table 7-5: **The CAP** by **Model Sector**

		Import tariffs MT	Variable Export Levies VEL	Market Inter-vention MI	Set Aside SA	Area Payments AP	Compens-atory Payments CP	Output Quotas OQ	Headage Payments HP
Crops									
WHT	Wheat	MT	VEL	MI	SA	AP	CP		
GRO	Other Grains	MT	VEL	MI	SA	AP	CP		
V_F	Vegetables, Fruit & Nuts	MT		MI					
OSD	Oilseeds	MT			SA	AP	CP		
C_B	Sugar cane and beet	MT	VEL	MI				OQ	
OAG	Other Agriculture	MT	VEL	MI					
Livestock									
CTL	Cattle, Sheep & Goats	MT	VEL	MI					HP
OAF	Other Animal Products	MT	VEL						
RMK	Raw Milk							OQ	
Food Products									
CMT	Cattle Meat	MT	VEL	MI					
OMT	Other Meat	MT	VEL						
SGR	Processed Sugar	MT	VEL	MI					
VOL	Vegetable Oils	MT	VEL						
MIL	Milk and Milk Products	MT	VEL	MI					
OFD	Other Food	MT							

flow; i.e. the UK tariff on any import from the USA may be different from the import of a good from Canada. There are three reasons why tariffs differ according to the region from **which** imports are sourced, despite the Most-Favoured Nation principle of the GATT, which states **that** all trading partners should be treated equally. Firstly, the Generalised System of Preferences gives lower tariff rates to imports from LDCs, so that any source region partly or wholly composed of LDCs may face lower tariffs when entering a developed region. Secondly, the sectors are aggregated (in the case of manufactures, highly aggregated), and while the MFN principle applies to each good that has been aggregated into a sector, the aggregated good may be composed differently according to the source region. Thirdly, customs unions and free trade areas have zero tariffs internally. The calculations for Table 7-6 exclude intra-EU trade, where tariffs are zero; the tariffs for EU regions are therefore the average tariff on imports from outside the EU. Tariffs are modelled as price wedges between worid c.i.f prices and domestic prices.

While the GTAP database contains very detailed tariff data. it only does so for 1995, while **the** base run requires that the Uruguay Round tariff reductions are implemented. It is therefore necessary to take tariff reduction data from elsewhere. Table 7-7 shows tariff reduction data **from**

Table 7-6: Average *Ad valorem* Import Tariffs in the GTAP Database (%)

	UK	Germany	**Rest** of EU	USA	**Cairns**	**LDCs**	**ROW**
Wheat	12,4	12,4	12.4	1.8	18.8	**4,5**	190,4
Other Grains	44,2	44,2	44,2	0	66,0	4,6	264,0
Vegetables. Fruit & Nuts	6,0	5,6	5,4	1.3	**8,5**	23.2	13.6
Oilseeds	-	-	-	-	19.4	8,5	8.2
Sugar cane and beet	76.6	76,6	76,6	63,8	30,0	12.5	64.1
Other Agriculture	7.1	5.3	9,8	3.7	20,8	21,8	8.9
Cattle. Sheep & Goats	111.2	111.2	111.2	0,01	**9,2**	9,0	16.4
Other Animal Products	0,7	1,2	0,7	0.3	32,7	21.5	4.6
Raw Milk	-	-	-	-	-	-	-
Cattle Meat	111.2	111.2	111.2	0.01	20,7	12.2	41.6
Other Meat	18.7	18.7	18,7	1.8	21.0	11.0	41.8
Processed Sugar	-	-	-	-	10,0	25,2	21.2
Vegetable Oils	116.3	116.3	116.3	51.8	48,5	16,3	100.7
Milk and Milk Products	76.6	76,6	76,6	63.8	**9,4**	19,7	42.9
Other Food	10.9	10.7	10,6	7.0	14.0	34.0	7,3
Primary	0.1	0.1	0.2	0.2	10.0	5.4	I.1
Manufactures	4.2	4,3	4.0	2.8	11.8	22.8	2.2
Services	-	-	0,04	-	-	0,2	1.4

Source: calculated from the GTAP database

Harrison *et al.* (1995). which have been aggregated to match the commodities and regions in this model. It is assumed that no tariff reductions have taken place by 1995. Note that these tariff reduction data takes account of 'dirty' tariffication; for most agricultural products in the EU, no tariff reduction takes place.

7.3.2 Modelling of Domestic Agricultural Policies Outside the EU

Modelling of other agricultural polices explicidy is not possible because with the excepdon of the USA. all other countries are contained within aggregate regions. Therefore all other regions will be modelled using simple reduction criteria: tariff reductions are as shown in Table 7-7. Regions will meet AMS reductions by reducing *ad valorem* rate equivalents for PSE in agriculture and food sectors.

The AMS reduction of 20% is applied to the Cairns Group, LDC and ROW regions, and for the USA is 13.3%. because of the "blue-box" exemptions for deficiency payments.

Table 7-7: Uruguay Round tariff reductions (% reduction) from Harrison *et al.*

	UK	Germany	Rest of EU	USA	Cairns	LDCs	ROW
Wheat	0.0	0,0	0,0	69.2	82.4	21.5	51.2
Other Grains	0.0	0,0	0.0	0,0	70.8	0,0	53.0
Vegetables. Fruit & Nuts	0.0	0,0	0.0	0,0	16,7	13.1	8.5
Oilseeds	0.0	0,0	0.0	0,0	17,8	6,6	8.1
Sugar cane and beet	0.0	0,0	0.0	0.0	13.2	12.2	7.7
Other Agriculture	0.6	0,3	0.5	0.1	18,3	7,3	9.4
Cattle. Sheep & Goats	9.4	9,4	9,4	68.8	61.1	3,0	26.3
Other Animal Products	9.4	9,4	9,4	68.8	42.6	5,4	36.4
Raw Milk	0.0	0,0	0,0	0.0	0,0	0.0	0.0
Cattle Meat	9.4	9,4	9,4	68.8	58,8	14.3	36,2
Other Meat	9.4	9,4	9,4	68,8	57,0	16.5	34.9
Processed Sugar	0.0	0,0	0,0	0,0	27,4	2,3	55,7
Vegetable Oils	0.0	0,0	0,0	0,0	1,6	0,0	2.4
Milk and Milk Products	0.0	0.0	0,0	0,0	24,9	1.9	38.5
Other Food	0.0	0.0	0.0	0,0	38,4	8.9	48.1
Primary	43.8	48.4	51.4	19.0	11.8	8.2	26.1
Manufactures	38.7	38.3	39.2	31.9	24.7	8.1	23.9
Services	0.0	0,0	0,0	0.0	0.0	0,0	0.0

(*) the final tariff t_f equals $t_b(1-t_r)$ where t_b is the base tariff and t_r is the tariff reduction shown here.

source: calculated from Harrison *et al.* (1995) and the GTAP database

Table 7-8: Export Subsidy Expenditure in the GTAP Database (1995 US$ million)

	UK	Germany	Rest of EU	USA	Cairns	LDCs	ROW
Wheat	16	37	168	99	1	0	2
Other Grains	56	178	189	0	44	0	43
Vegetables. Fruit & Nuts	0	0	0	0	0	0	7
Oilseeds	0	0	0	0	0	0	118
Sugar cane and beet	18	30	64	8	21	361	12
Other Agriculture	1	0	108	0	0	0	75
Cattle, Sheep & Goats	162	263	418	0	0	0	136
Other Animal Products	44	58	212	46	189	0	607
Raw Milk	0	0	0	0	0	0	0
Cattle Meat	135	309	1,145	1	83	43	244
Other Meat	29	49	604	58	1,256	3	534
Processed Sugar	0	0	0	0	0	16	774
Vegetable Oils	368	1,001	4.962	438	537	1	1,696
Milk and Milk Products	158	362	1,081	226	2	23	91
Other Food	7	0	41	0	1,826	48	128

source: calculated from the GTAP database

7.3.3 Export Subsidies

Table 7-8 and Table 7-9 show the export subsidy data in the GTAP database, in value (Table 7-8) and *ad valorem* (Table 7-9) form. Export subsidies are on the same bilateral basis as import tariffs (and the EU *ad valorem* rates exclude intra-EU trade, where subsidy rates are zero). As with import tariffs, there is a necessity to include data on post-Uruguay Round levels of export subsidies because the commitments of 21% reduction in subsidised exports and 36% reduction in export subsidies are reductions relative to the base period 1986-90.

Table 7-10 contains data from USDA (1998) on the quantities of subsidised exports from the EU that are permitted under the Uruguay Round agreement. Column (b) lists the commodity categories used in USDA (1998), except where the category is in parentheses, in which case that row is a summary measure calculated here to match the USDA commodity categories with the model commodity aggregation. The corresponding model category is given in column (a). Some categories (e.g. Wheat and Coarse Grains) match exactly; other categories are matched one-to-one with model commodities even though the match is not exact (e.g. Olive Oil is matched with VOL • vegetable oils). In some cases the USDA categories are less aggregated than the model categories (e.g. the milk products) in which case the quantities are summed to match a single model commodity. In some cases (e.g. Sugar) the USDA categories identify commodities that the model (and GTAP) commodity categorisation splits into an agricultural good (C_B, sugar cane

Table 7-9: *Ad Valorem* Export Subsidy Rates in the GTAP Database (%)

	UK	Germany	Rest of EU	USA	Cairns	LDCs	ROW
Wheat	11.0	11.0	11.0	1.7	0,3	0,0	0,9
Other Grains	30.7	30,7	30,7	0.0	**2,9**	4,0	9.2
Vegetables, Fruit & Nuts	0,0	0,0	0,0	0.0	0,0	0,0	0,2
Oilseeds	0,0	0,0	0,0	0.0	0,0	0,0	14,9
Sugar cane and beet	43,4	43,4	43,4	39,0	1.1	16,5	10.8
Other Agriculture	0,3	0,0	3,5	0,0	0,0	0,0	1,2
Cattle, Sheep & Goats	52,6	52,6	52,6	0,0	0,0	0,0	13,6
Other Animal Products	15,7	15.7	15.7	1.8	**8,3**	0,0	23,6
Raw Milk	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Cattle Meat	52,6	52,6	52,6	0,0	1,2	11.7	38,1
Other Meat	15.7	15,7	15,7	1,8	23,9	14.1	13,5
Processed Sugar	0,0	0,0	0,0	0,0	0,0	3,2	41,3
Vegetable Oils	53,8	53,8	53,8	34.1	13.3	0,6	54,2
Milk and Milk Products	43,4	43,4	43,4	39,0	0,2	1.1	17,4
Other Food	0,2	0,0	1,2	0,0	**7,2**	0,6	**1,6**

source: calculated from the GTAP database

and beet) and a processed good (SGR, processed sugar). In these cases the resulting percentage data in column (g) must be used in both model sectors.

Columns (c) to (f) are taken directly from USDA, and give the base quantity (column c), the schedule commitments both in 1995/6 (column d) and 2000/01 (column t), and the EU notification to the WTO (column e) - the quantity that the EU declared that it subsidised in 1995/6.

As can be seen from Table 7–10, for some commodities such as Wheat and Coarse Grains, the EU notification for 1995/6 is substantially below its schedule commitment for this year, and for 2000/01 while for other commodities, such as Olive Oil and Fresh Fruit and Vegetables, the EU was very close to the commitment in 1995/96, and needs large reductions in subsidised exports by 2000/01.

Column (g) is calculated from columns (e) and (f), and gives the percentage increase in subsidised exports that is permitted under the terms of the Uruguay Round Agreement, from the actual quantity in 1995/96 to the 2000/01 commitment. These data will be used in the model as the maximum increase in exports where the Uruguay Round Agreement is in force.

There are obvious difficulties in using these data: the matching of commodity categories is not perfect, but this is to be expected when using an aggregated model. Furthermore the export commitments are commodity-specific commitments, so the aggregated nature of the model will never capture the full detail of these commitments. The use of marketing years in reporting data to the WTO is unfortunate in the current context, where the rest of the model is calibrated to a calendar year. Table 7-11 gives similar USDA data for export subsidy e.xpenditure. in millions of ECU. with the same commodity categories matched to model commodities as for Table 7-10. Again, a percentage reduction from 1995/96 to the 2000/01 figure is calculated from the data in the last column.

It should be noted that the use of percentage reductions is necessary. rather than transferring ECU values into dollars and using the 2000/01 value as the constraint for two reasons: firstly, the different base year to the data means that GTAP database values do not match directly with the USDA values. and secondly. because the -messy" commodity matching means that for some categories the GTAP data and USDA data are very different. When converted at the July 1995 exchange rate of 1.3311 $/ECU. for example. the GTAP wheat subsidy expenditure is 221.0 m. ECU. corresponding relatively well to the EU notification of 118.7 m. ECU in Table 7-11, but the total GTAP subsidy expenditure for milk and milk products is 6.331.8 m. ECU (USDA data for notification is 1,562.3 m. ECU).

These data will be used in the model to set the EU agricultural export limits, with the exception that, for Wheat and Other Grains, 1995 was an unusual year in that subsidies were applied to these e.xports for only a part of the year, accounting for the low mtio of 1995/96 notified exports to 1995/96 value commitment in Table 7-10. EU data for 1995 exports (22.300[2] for Wheat and 15.724 for Other Grains) will be used, so that the EU must reduce the quantity of exports by 35.3% (Wheat) and 31.0% (Other Grains) to meet the 2000/01 commitments. Table 7-12 shows the percentage changes in allowable exports and subsidy expenditure that will be used in the model.

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[2] From European Commission (1996), in thousands of tons.

Table 7–10: EU Subsidised Export Quantity Commitments (000 t)

(a)	(b)	Base Volume 1986-90 (c)	Schedule Commitment 1995/96 (d)	EU Notification 1995/96 (e)	Schedule Commitment 2000/01 (f)	Change Allowed from 1995/96 (g)
WHT	Wheat	18,276.0	20,408.1	2,768.8	14,438.0	421.5%
GCO	Coarse Grains	13,725.6	13,690.2	6,596.4	10,843.2	64.4%
	Fruit and Vegetables, fresh	[illegible]	920.3	[illegible]	[illegible]	-17.2%
	Fruit and Vegetables, processed	[illegible]	175.1	93.6	[illegible]	53.1%
V_F	(Fruit and Vegetables Total)	[illegible]	1,095.4	[illegible]	896.7	-10.6%
OSD	Rapeseed	131.4	[illegible]	0.0	103.8	n/a
C_B, SGR	Sugar	1,612.0	1,555.6	[illegible]	1,273.5	48.7%
	Rice	[illegible]	163.0	88.6	[illegible]	50.6%
OAG	(Other Agriculture total)	[illegible]	[illegible]	88.6	[illegible]	[illegible]
CTL, CMT	Beef Meat	1,040.1	1,137.0	1,019.1	821.7	-19.4%
	Pigmeat	[illegible]	541.8	378.2	443.5	[illegible]
	Poultry Meat	[illegible]	[illegible]	[illegible]	286.0	[illegible]
	Eggs	125.0	[illegible]	95.1	[illegible]	3.9%
OAP, OMT	(Other Meat total)	1,048.4	[illegible]	891.4	828.3	-7.1%
VOL	Olive Oil	145.6	140.5	135.5	115.0	-15.1%
	Butter and Buttermilk	505.5	487.8	146.4	[illegible]	172.7%
	Skim Milk Powder	344.9	[illegible]	241.2	272.5	13.0%
	Cheese	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Other Milk Products	1,212.8	1,185.4	1,156.7	958.1	[illegible]
MIL	(Milk Products Total)	[illegible]	2,434.7	1,966.6	1,951.2	-0.8%
	Wine	29,174.0	[illegible]	[illegible]	2,304.7	6.6%
	Raw Tobacco	140.3	[illegible]	11.2	110.8	[illegible]
	Alcohol	1,452.4	[illegible]	[illegible]	1,474	[illegible]
OFD	(Other Food and Drink Total)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table 7–11: EU Export Subsidy Value Commitments (million ECU)

		Value Commitment 1995/96	Value Commitment 2000/01	EU Notification 1995/96	Change Allowed from 1995/96
(a)	(b)	(c)	(d)	(e)	(f)
WHT	Wheat	2,309.0	1,477.8	118.7	1145.0%
GRO	Coarse Grains	1,605.7	1,027.6	303.4	238.7%
	Fruit and Vegetables, fresh	77.8	49.7	70.4	-29.5%
	Fruit and Vegetables, processed	[illegible]	7.8	[illegible]	-30.9%
V_F	(Fruits and Vegetables Total)	89.8	57.5	81.7	-29.7%
OSD	Rapeseed	40.7	26.0	0.0	n/a
C_B, SGR	Sugar	733.1	469.2	379.0	23.8%
	Rice	53.6	34.9	[illegible]	15.3%
OAG	(Other Agriculture Total)	53.6	34.9	[illegible]	15.3%
CTL, CMT	Beef Meat	1,922.6	1,230.5	1,506.5	-18.3%
	Pigmeat	288.8	184.8	[illegible]	83.9%
	Poultry Meat	136.3	87.2	[illegible]	-24.7%
	Eggs	98.8	63.2	[illegible]	[illegible]
OAP, OMT	(Other Meat/Animal Products Total)	523.9	336.3	229.3	[illegible]
VOL	Olive Oil	79.8	51.1	62.1	-17.8%
	Butter and Buttermilk	1,392.1	890.9	256.2	247.8%
	Skim Milk Powder	[illegible]	260.0	[illegible]	[illegible]
	Cheese	594.1	380.2	437.6	[illegible]
	Other Milk products	1,024.7	655.8	727.6	-9.9%
MIL	(Milk Products Total)	3,417.1	[illegible]	1,562.3	40.0%
	Wine	57.6	36.8	51.1	-28.0%
	Raw Tobacco	96.6	[illegible]	182	239.7%
	Alcohol	141.2	90.3	51.2	76.5%
OFD	(Other Food and Drink Total)	295.3	[illegible]	120.5	58.8%

Table 7-12: EU Export Subsidy Commitments: permitted changes in the model

		Allowable increase in quantity of subsidised exports (%)	Allowable increase in export subsidy expenditure (%)
WHT	Wheat	-35,3	+1146.0
GRO	Other Grains	-31.0	+238,7
V_F	Vegetables and Fruit	-10,6	-29,7
OSD	Oilseeds	0	0
C_B	Sugar cane and beet	+48,7	+23,8
OAG	Other Agriculture	+50.6	+15.3
CTL	Cattle, Sheep & Goats	-19,4	-18.3
OAP	Other Animal Products	-7.1	+46,2
RMK	Raw Milk	n/a	n/a
CMT	Cattle Meat	-19,4	-18,3
OMT	Other Meat	-7.1	+46,2
SGR	Processed Sugar	+48,7	+23.8
VOL	Vegetable Oils	-15.1	-17.8
MIL	Milk and Milk products	-0,8	+40.0
OFD	Other Food	+35,9	+56,8

Modelling Export Subsidies: The Base Case

The Base Case is intended primarily to calibrate non-agricultural productivity rates, but will also be compared with the other scenarios. Modelling of export policies prior to the Uruguay Round is not a concern here, so fixed *ad valorem* export subsidy rates are used.

Modelling export subsidies: non-EU regions under Uruguay Round constraints

Figure 7.1 gives a graphical partial equilibrium model of an export subsidy that shows both the volume and the cost of subsidised exports. In the top panel, export supply, XS, and demand, XD, would, in the absence of a subsidy, result in free-trade quantity Q_f being exported. With subsidy SUB creating a wedge between the domestic price P_d and world price P_w, a quantity Q_0 is exported. The export subsidy expenditure schedule XE can be derived in the lower panel relating the quantity of exports to the subsidy expenditure. The subsidy SUB results in a level of subsidy expenditure E_0.

Figure 7.1: Non-EU Export Subsidies

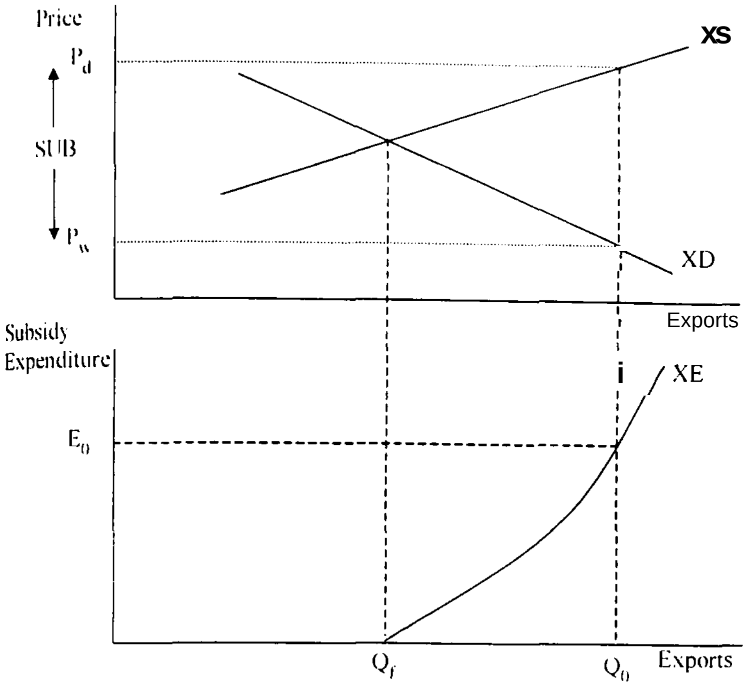
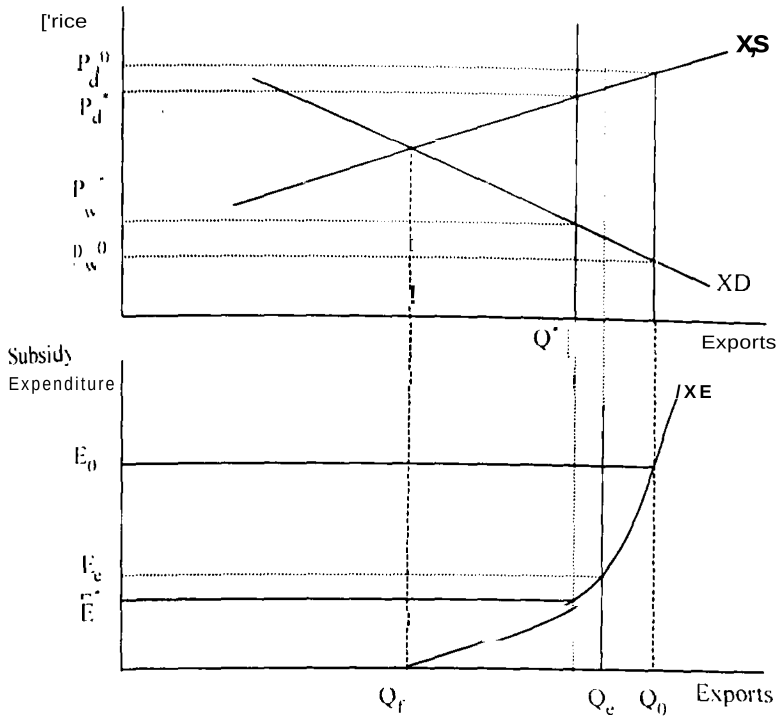


Figure 7.2 represents the two Uruguay Round export subsidy commitments. From an initial export quantity Q_0, the quantity of subsidised exports must fall to at most Q^*. In addition, from the initial level of export subsidy expenditure EQ. expenditure must fall to at most E_e, corresponding to a quantity Q_e. The subsidised quantity limit is therefore the lower of Q_e and 0^*. and in the case shown the quantity commitment Q^* is the binding commitment: the per-unit subsidy must fall to $P_d^* - P_w^*$, with a quantity Q^* exported and expenditure on export subsidies of $E^* < E_e$.

The quantity of subsidised exports is not the same as the export quantity; there are three cases where a sector's subsidised exports are lower than its total exports; where subsidies are applied on exports to some regions, where subsidies are applied on a subset of sectoral output, and where subsidies are applied for part of a year. The first case is the only one that can be dealt with in the model, and applies principally to the EU because intra-EU exports are not subsidised, with some minor instances for other regions. In these cases, the Uruguay Round constraints are applied to subsidised exports only.

Figure 7.2: non-EU export subsidies with Uruguay Round constraints

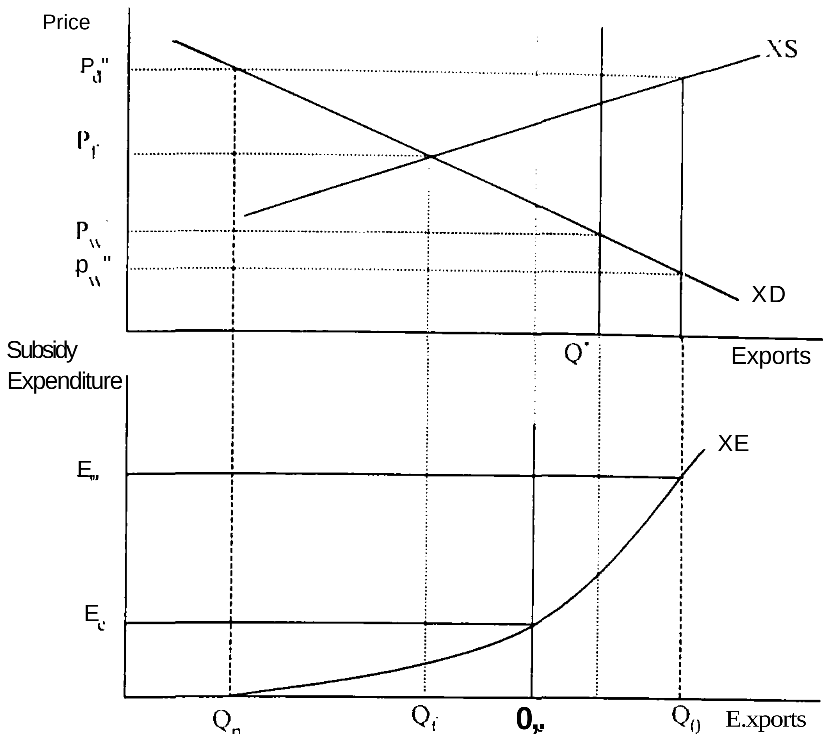


The required percentage reductions (21% cut in subsidised export quantity for developed countries, 14% for LDCs; 36% cut in export subsidy expenditure for developed countries, 24% for LDCs) are calculated prior to aggregating the database, so the required rate for the ROW and Cairns Group regions, which both include developed countries and LDCs. will be between the developed and LDC rates.

Modelling Export Subsidies: The EU under Uruguay Round Constraints

The EU has different arrangements to meet the Uruguay Round export constraints. Because the purpose of variable export subsidies in the EU is to maintain a certain level of domestic market price despite changes in world prices, the rates cannot be reduced. Instead, the variable export subsidy will be modelled as continuing to meet the difference between domestic and world prices, with any goods that cannot be exported under the Uruguay Round constraints held as stocks. In the top panel of Figure 7.3, to ensure that exports do not rise above Q^*, the EU intervention agencies will purchase $Q_0 - Q^*$. Supply of goods is therefore unchanged at Q_0, so the domestic price will remain at P_d^0. The world price will still rise to P_w^* because Q^* is to be exported, so the variable export levy must make up the difference $P_d^0 - P_w^*$.

Figure 7.3: EU Exports under Uruguay Round constraints



Variable export levies change the export subsidy expenditure curve, so that the export subsidy expenditure is the product of the export volume and the difference between P_d^0 and the world price given by XD, as shown in the top panel of Figure 7.3. Even at the 'free-trade' export quantity Q_f, the EU would still apply an export subsidy P_d^0 - Pf . In the case shown, the limit on subsidy expenditure, E_e, defines a volume of exports, Q_e, that is less than the volume limit, Q^*. Hence it is the subsidy expenditure commitment that is binding in this case.

It is likely that tariff reductions and/or income growth in other countries will stimulate demand for EU exports, and this may shift the demand for EU exports far enough to remove the necessity for subsidies at all. The EU can then export above the Uruguay Round constraints, and possibly above the original level of exports, at the world price, with the additional exports coming either from the domestic market or from stocks. Because it is not possible for the model to determine the level of stocks that is built up between 1995 and 2005, it assumes that any extra exports come from purchases from the market. Thus the rules for stock purchases that apply within the model for EU exports are one-sided: the EU can build up stocks, but cannot run them down.

7.3.4 Market Intervention

Market prices were relatively high in the EU in 1995 (relative to historical levels and to intervention prices), with the result that purchases of stocks occurred for only a few commodities.[3] Because the values of intervention purchases were low, and also because they occurred in commodities that exist in the model as part of aggregated commodity groupings, the model has been calibrated to zero intervention purchases for all goods. Table 7-13 shows the intervention price data to be used in the model.

Table 7-14 shows EU data for the ratio of market and intervention prices, and makes it evident that for cereals market prices were substantially higher than intervention prices in 1995. These data are used in Table 7-15 to show (in the first three columns) how far the market price can fall before reaching the intervention price. Table 7-15 also shows the corresponding data for other sectors in the model; where price ratio data are unavailable (in most cases because of the highly aggregate nature of the commodity categories) a 5% difference between market price and

Table 7-13: Intervention Prices (ECU/t)

		Intervention Price 1995	Intervention Price Agenda 2000
WHT	Wheat	119.19	95.35
GRO	Other Grains	119.19	95.35
CTL	Beef	2780	1950
RMK	Raw Milk	(various)	10% average reductions
CMT	Cattle Meat	2780	1950
MIL	Milk and Milk products	(various)	10% average reductions
OFD	Other Food	(various)	no reductions

Table 7-14: Cereals Market Prices as a percentage of the Intervention prices, 1995 average

	UK	Germany	Rest of EU
Wheat average	127.6	122,3	126.7
- common wheat	127.6	122,2	122,8
- durum wheat	155.1	155.1	151.9
Coarse Grains average	111.2	111.7	117.1
- Barley	111.2	110.0	114.6
-Rye	110.7	110.7	110.6
• Maize	-	121.2	119.8

source: European Commission (1996), table 4.1.6.2

Table 7-15: Intervention Prices as a percentage of the 1995 Market Price

	1995			Agenda 2000		
	UK	**Germany**	**Rest of EU**	UK	Germany	**Rest of EU**
Wheat	78.37	81.77	78,93	62,f)9	65.41	63.14
Other Grains	89.93	89.53	85,40	71.68	71,36	68,07
Cattle, Sheep & Goats	95.00	95,00	95,00	66:64	66,64	66,64
Raw Milk	95,00	95,00	95,00	85.50	85,50	85,50
Cattle Meat	95,00	95,00	95,00	66,64	66.64	66,64
Milk and Milk products	95,00	95,00	95,00	85,50	85,50	85,50
Other Food	100,00	100,00	100,00	100,00	100,00	100,00

intervention price is assumed, except where small stock purchases took place in 1995. in which case there is assumed to be no difference between the market and intervention prices.

Table 7-15 also shows the Agenda 2000 intervention price as a percentage of the 1995 market price. given the 1995 ratio and the Agenda 2000 changes in intervention prices.

Modelling Intervention Prices

The modelling of intervention prices uses a simple inequality. that the market price must be equal to or greater than the intervention price. When the market price is equal to the intervention price, stocks are bought from the market, and when the market price is above the intervention price, **no** stocks are bought. Like the stock buying to meet the Uruguay Round export constraints, this is one-sided: stocks may be bought but are not sold. Intervention prices are modelled in all scenarios except the CAP abolition scenario.

7.3.5 Compensation Payments

Table 7-16 shows compensation payments for cereals and oilseeds. When the model is subsequently calibrated to expenditure data for compensation payments. the payments will be paid as a subsidy to land (with the exception of set-aside compensatory paymems, which are paid to the land owners). The percentage rate changes from Table 7-16 can then be applied to simulate the Agenda 2000 compensation payment changes.

[3] 328,1 m, ECU of fruit and vegetables. 175.6 m, ECU of wine, and 21.1 m, ECU of fishery products were withdrawn from the market (European Commission (1996) table 3,4,4), Storage and disposal costs were incurred in other sectors because of stock levels built up in previous years.

Table 7-16: Compensation Payments and Set-Aside Compensatory Payments

Crop	1995	Agenda 2000	Percentage
Cereals	262 ECU/ha	321 ECU/ha	+22,52%
Oilseeds	438 ECU/ha	321 ECU/ha	-26,71%
Set-aside	334 ECU/ha	321 ECU/ha	-3,89%

Modelling Compensation Payments

Compensation payments are modelled as input subsidies on land, with the exception of set-aside, which is modelled as a direct transfer of income between the government in each EU region and farmers in each region. Arable land in EU regions is modelled as a CET function to prevent large shifts of land between arable and non-arable sectors,[4] which prevents large changes in the total value of compensation payments. The elasticity of transformation (set to unity in the model) determines the ability of farmers to transfer land between arable sectors.

7.3.6 **Set-Aside**

Table 7–17 shows set-aside areas. In 1995 the set-aside areas were comprised of compulsory set-aside (17.5% of commercial farm land[5]) and voluntary Five-year set-aside. Agenda 2000 abolishes compulsory set-aside, but retains voluntary set-aside. We use a EC projection that, under Agenda 2000, total voluntary set-aside will be 3 m. ha., and assign this to countries in the same proportions as was the take-up of voluntary set-aside in 1995.

Modelling Set-Aside

Set-aside is modelled by the withdrawal of land. The GTAP database holds data on the 1995 dollar value of land used by sectors. The endowment of arable land in each region (as noted above, arable land is held in a CET nest, and is separate from other land) is increased, as in 1995 endowments of land were 13.6% higher than land use. An average[6] of 13.6% of land is then

4 The •sticky factors' approach.

5 i.e. allowing for small farm exemption,

6 Kates differ between EU regions as shown in Table 7–17.

Table 7-17: Set-Aside Areas {'000 ha)

	UK	**Germany**	**EU-15**	**EU-13**
Total Base Area	4461	10156	53561	38944
Compulsory Set-Aside	597	1321	6411	4493
	13.4%	13,0%	12.0%	11.5%
Five-year Set-Aside	37	151	848	660
	0,8%	1.5%	1.6%	1,7%
Total Set-Aside	634	1472	7259	5153
	14.2%	14,5%	13.6%	13.2%
Agenda 2000: Voluntary Set-Aside	131	534	3000	2335
	2.9%	5,3%	5,6%	6.0%

source: European Commission (1996) table 3.5.7,1

withdrawn in the Base Case and Uruguay Round simulations; only 6% of land is withdrawn in the Agenda 2000 simulation, and no land is withdrawn in the CAP abolition scenario.

7.3.7 **Headage Payments**

As a direct income support, headage payments operate in a similar method to compensation payments, except that they are treated as a subsidy to capital in the livestock sector rather than a subsidy to land.

Table 7–18 shows the changes in headage payments under Agenda 2000, and Table 7-19 reports the changes to payment ceilings. Given that expenditures on suckler cow and male bovine headage payments are roughly equal. the average percentage change in payment would be the direct average of the percentage change by cattle type. With the addition of the dairy cow payment, the effective average rate could increase by some 100-120%. Therefore an average increase of 110% has been used to model the effects of Agenda 2000 on headage payments.

Modelling Headage Payments

Headage payments are treated as a subsidy to capital in the Cattle, Sheep & Goats sector (CTL), and capital in this sector is held constant.

7.3.8 **Output Quotas**

Output quotas exist in the raw sugar cane and beet (C_B) and raw milk (RMK) sectors. Output of these sectors in each EU region is fixed at 1995 levels during the Base Case and Uruguay Round scenarios. A 2% increase in milk quota is accounted for in the Agenda 2000 scenario, and **all** quotas are removed in the CAP abolition scenario.

Table 7-18: Headage payments (ECU/head)

	1995	Agenda 2000	Percentage Change
Suckler Cow	145	215	48%
Male bovine - bull	135	368	173%
- steer	109	232	113%
Dairy cow	0	70	n/a

Table 7-19: Headage payment ceilings (million animals)

	1995	Agenda 2000	Percentage Change	1995 Expenditure (m ECU)
Suckler Cow	9.976	10.285	3,1%	1046,7
Male bovine	9.038	9,095	0.6%	957,1
Dairy cow	0	20.250	n/a	0

7.4 PRODUCER SUBSIDY EQUIVALENTS

The GTAP database assigns all domestic support to a single output subsidy, taken from OECD Producer Subsidy Equivalent (PSE) calculations as an average over a number of years. As a result, the values in the database do not correspond with 1995 support levels. Table 7-20 shows the producer subsidies in the data, and Table 7-21 gives these subsidies as a percentage of output. The total value of producer subsidies in the EU. from Table 7-20, is $49,014 m., corresponding closely to the total CAP budgetary expenditure in 1995 of $49,657 m[7].

The similarities between these total figures do however hide the fact that they are compiled in different ways (the GTAP data for example, are on the total domestic support; CAP budgetary expenditure includes expenditure on export refunds) and with different base periods (the OECD data from which the GTAP data are derived are taken as averages over several years).

After the deduction of export refimds from CAP budgetary expenditure, expenditure on other measures is $40,514 m., 12% of which ($4,804 m.) is expenditure on EAGGF Guidance., and a further 2.1% ($852 m.) is EAGGF Guarantee expenditure not related to coinmodity, such as food aid refunds, rural development schemes linked to market operation, and accompanying measures.

[7] These. and the other CAP e.xpenditure data used here, are taken from European Commission (1996) tables 3.4.1, 3,4,2, 3.4.3.1 and 3.4.4. converted at the July 1995 exchange rate of 1.3311 $/ECU,

Table 7-20: Producer Subsidies from the GTAP Database (1995 USS million)

	UK	Germany	Rest of EU	USA	Cairns	LDCs	ROW
Wheat	1,527	1,787	6,212	2,166	930	836	1,121
Other Grains	841	1,983	6,361	4,248	263	1,177	848
Vegetables, Fruit & Nuts	0	412	191	0	0	0	0
Oilseeds	536	734	3,906	1,270	522	591	304
Sugar cane and beet	0	0	0	213	172	511	754
Other Agriculture	101	183	854	478	170	641	9,129
Cattle, Sheep & Goats	1,813	1.393	5,094	3,433	734	106	1,527
Other Animal Products	709	2,559	3.682	1,057	688	0	2,573
Raw Milk	727	1,171	3,234	931	401	0	4,436
Cattle Meat	246	6	232	0	0	12	87
Other Meat	396	8	323	0	0	0	215
Processed Sugar	52	12	127	0	0	0	0
Vegetable Oils	542	154	595	0	0	0	0
Milk and Milk Products	116	8	187	0	0	0	0
Other Food	0	0	0	0	0	0	0
Primary	0	2,120	0	0	0	0	0
Manufactures	0	0	0	0	0	0	0
Services	0	0	0	0	0	0	0

source: calculated from GTAP database

Table 7-21: Producer Subsidies from the GTAP Database as a Percentage of Output

	UK	Germany	Rest of EU	USA	Cairns	LDCs	ROW
Wheat	58,0	58,0	58.0	17,6	7,2	2,4	8,3
Other Grains	53,1	53.1	53.1	8,5	1,7	3,6	5,5
Vegetables, Fruit & Nuts	0,0	4,9	0.4	0,0	0,0	0,0	0.0
Oilseeds	109,5	109.5	109.5	7.6	2,9	1,7	7,2
Sugar cane and beet	0,0	0,0	0,0	8.2	0,8	1.6	9,6
Other Agriculture	3,1	4,9	2,4	1.7	0.2	0,4	8,9
Cattle, Sheep & Goats	22.0	22,0	22,0	4,9	2,2	0,3	5,1
Other Animal Products	9.0	9,0	9.0	4,2	2,0	0,0	3,3
Raw Milk	8.9	8,9	8.9	4,0	2,1	0,0	11.1
Cattle Meat	2,9	0,0	0,5	0,0	0,0	0,1	0.2
Other Meat	3.1	0.0	0,5	0,0	0,0	0,0	0.3
Processed Sugar	4,2	0.0	0,7	0,0	0,0	0,0	0.0
Vegetable Oils	3,8	0.4	0,7	0,0	0,0	0,0	0.0
Milk and Milk Products	3.6	0.0	1.2	0.0	0.0	0.0	0.0
Other Food	0.0	0.0	0,0	0.0	0.0	0.0	0,0
Primary	0.0	5.4	0.0	0.0	0.0	0.0	0.0
Manufactures	0,0	0.0	0.0	0.0	0.0	0,0	0.0
Services	0.0	0.0	0.0	0.0	0,0	0,0	0.0

source: calculated from GTAP database

7.5 CALIBRATION

The EU agricultural sectors are calibrated to various data. After calibration, a residual factor will be accounted for by EAGGF Guidance, EAGGF Guamntee expenditure not related to commodity, and miscellaneous commodity costs such as storage and disposal costs.

Arable Sectors Calibration

The arable sectors are calibrated to the target area payments and set-aside compensation payments in Table 7-22.

Cereals area payments are divided into Wheat and Other Grains in direct proportion to the GTAP subsidies in those sectors in the whole EU-15 (50.9% and 49.1%), so that Wheat area payments are 5,987 m. ECU, and Other Grains area payments are 5,773 m. ECU. Oilseeds area payments are set at 2,010 m. ECU. The set-aside target is divided into the PSE figures for wheat, other grains and oilseeds in direct proportion to the GTAP subsidies in those sectors (39.9%, 38.5% and 21.7% respectively).

Set-aside payments are made to land owners not production sectors, but in order for the database to represent an initial equilibrium, any value deducted from production subsidy must in some way also be deducted from firms" costs, so the set-aside payments are deducted from factor payments in the arable sectors.

Table 7-22: Area **and** Compensation Payments (1995)

	1995 **Value** (m. ECU)
Cereals Area Payments	11,760
Oilseeds Area Payments	2,010
Set-aside Compensation Payments	2,370

Table 7-23**: Arable Sector Calibration**

	Area Payments m. ECU	Area Payments $ m.	Set-aside compensation m. ECU	Set-aside compensation $m.	Total Payments $ m.	Residual $ m.	PSE $ m.
Wheat	5,987	7,970	945	1,258	9,526	298	9,526
Other Grains	5,773	7,684	911	1,213	9,185	288	9,185
Oilseeds	2,010	2,676	514	684	5,176	1,817	5,176
Total	13,770	18,329	2,370	3,155	23,887	2,403	23,887

Table 7-23 shows the arable sector calculations, with a residual value of subsidy to ensure that the total subsidies accounted for match PSE data in the GTAP database.

Sugar Sector Calibration

Raw sugar cane and beet (C_B) has no subsidy in the GTAP database, but has an output tax of 8%. Following Frandsen *et al.* (1998). the data have been recalibrated to include a 20% *ad valorem* equivalent tax to represent the sugar quota regime in addition to the existing 8% output tax.

Raw Milk Sector Calibration

Milk quotas are also modelled. again following Frandsen *et al.*. by calibrating the *ad valorem* equivalent of the quota to 20%. The subsidy in the GTAP database is retained in addition to the quota.

Livestock Sectors Calibration

The beef and veal sector headage payment is calibrated to 1995 expenditures on cow premiums (1.046.7 m. ECU) plus special premiums (957.1 m. ECU)

Table 7-24: Recalibrated Subsidy Data, S million

	Area / Headage Payments	Set-aside Compensation	EAGGF Guidance	Storage, etc.	GTAP PSE
Wheat	7,970	1.258	43	255	9,526
Other Grains	7,684	1.213	42	246	9.185
Vegetables, Fruit & Nuts			87	516	603
Oilseeds	2.676	684	262	2.656	5.176
Sugar cane and beet			0	0	0
Other Agriculture			164	974	1,138
Cattle, Sheep & Goats	2,667		713	4.819	8,300
Other Animal Products			1,003	5.946	6,950
Raw Milk			741	4.391	5,132
Cattle Meat			70	415	484
Other Meat			105	622	727
Processed Sugar			45	266	**311**
Vegetable Oils			27	163	**191**
Milk and **Milk Products**			186	1,104	1,291
Other Food			0	0	**0**
Totals	**20,997** (42.8%)	**3,155** (6.4%)	**3,589** (7,3%)	**21,273** (43.4%)	**49,014**

Residual Calibration

The remainders after these calibrations, and the subsidies on other sectors, are counted as residuals. EAGGF Guarantee expenditure is divided amongst sectors in proportion to the size of the residual, with the remaining subsidy being treated as a PSE equivalent of all other forms of subsidy expenditure from storage costs, aids for private storage, disposal costs, food aid refunds, accompanying measures, and all other forms of CAP expenditure not accounted for elsewhere.

Table 7-24 shows the recalibrated protection data for the whole EU. The implied rates from this table are applied to each EU region (note that in Table 7-21 there is very little difference in EU subsidy rates between EU regions).

7.6 CONCLUSIONS

This chapter has outlined extensions to the model of Chapter 5. The purpose of these extensions is to enable full use *of* the additional features of the version 4 GTAP database. The inclusion of more agricultural sectors in this database allovvs various CAP programmes to be modelled, such as milk and sugar quotas, and arable sector programmes. This in turn allows further analysis of Agenda 2000 reforms, necessitating the use of a projected model and therefore modification of consumer preferences to include income elasticities. In addition, EU export subsidy limits have been included in a more detailed form: rather than 21% (quantity) and 36% (expenditure) reductions which are the rates applicable on the base period (1986-90) values, the appropriate limits have been imposed relative to 1995 values of subsidised exports and subsidy expenditures. Import tariff reductions have been taken from Harrison *et al.* (1995), accounting for 'dirty tarrification'. In all product groups, the EU is committed to lower levels of liberalisation with these Uruguay Round limits than in the model of Chapter 5. Chapter 8 will use this model to provide updated estimates of the effects of the Uruguay Round, and examine Agenda 2000 and CAP abolition.

CHAPTER 8

APPLIED GENERAL EQUILIBRIUM RESULTS FOR THE URUGUAY ROUND COMMITMENTS, AGENDA 2000 AND CAP ABOLITION IN 2005

8.1 INTRODUCTION

This chapter presents a set of the results from three policy simulations: (i) meeting the Uruguay Round commitments, (ii) Agenda 2000 reforms, and (iii) abolition of the CAP. These are identified in the tables as 'UR', 'Agenda 2000' and 'CAP' respectively. We report on changes in welfare, the prices and volumes of commodities, agricultural incomes, land use, CAP expenditure, the CAP budget. Welfare changes are decomposed according to consumer effect, producer effect and net tax revenue, and also by product.

8.2 MAIN WELFARE RESULTS

Table 8-1 reports the main welfare results for the Uruguay Round. Agenda 2000 and CAP Removal scenarios, showing the changes in equivalent variation in real 1995 billions of dollars, and as a proportion of the original EV. compared to the Base Case scenario.

Table 8-1: Welfare - Changes in Equivalent Variation Relative to Base Case

Regions	UR		Agenda 2000			CAP Removal		
	EV (Sbn)	(%)	EV (Sbn)	{%)	From UR	EV (Sbn)	(%)	From Agenda 2000
UK	-0.479	(-0,04)	0.105	(0,01)	0,583	1,905	(0,16)	1,800
Germany	-1.799	(-0,07)	-1.520	(-0,06)	0,279	0,930	(0.04)	2,450
Rest of EU	-4,163	(-0,08)	-3.147	(-0,06)	1.016	6,417	(0.13)	9,564
EU	-6.441	(-0,07)	-4,562	(-0,05)	1,879	9,251	(0.10)	13.814
USA	0,439	(0,01)	0,418	(0,00)	-0,021	3,008	(0,04)	2,590
Cairns Group	2,859	(0,07)	2.718	(0,07)	-0,141	6,921	(0,18)	4,203
LDCs	7,287	(0,20)	7,506	(0,20)	0.220	7,608	(0.21)	0.102
Rest of World	21,129	(0,23)	21,501	(0,23)	0,372	19,699	(0,21)	-1.801

8.2.1 The Uruguay Round

Welfare changes for the Uruguay Round are low compared to other studies, and the EU has a welfare loss in each region. With very little tariff liberalisation in the EU, and relatively modest reductions from 1995 needed to meet the Uruguay Round export subsidy constraints, the EU makes very little in the way of gains from its own liberalisation. It could possibly make gains from liberalisation in other regions, but the EU is a high-cost producer, and with the Uruguay Round limits on agricultural and food exports is unable to make gains from exporting to other regions. Two main sources of loss exist for the EU: third-country diversion effects and stock buying effects. As other regions liberalise tariffs both in agricultural and manufactured goods, they will draw imports away from the EU, leading to fewer EU imports of these goods at higher prices. Purchases of stocks will be necessary to meet the Uruguay Round commitments for many agricultural goods, and these will lead to welfare losses in this model, which measures welfare and equivalent variation in a static framework, and therefore does not allow for the fact that stocks purchased will be released and consumed at a later date.

Of the non-EU regions, only the Rest of the World group makes a significant gain from the Uruguay Round. This group, which includes Japan and the East Asian Newly Industrialised Countries, makes large gains from liberalisation in manufactures, particularly from Cairns Group and LDC liberalisation. Both the USA and the Cairns Group might hope to benefit from EU agricultural liberalisation, both in terms of improved access to EU markets through tariff reduction, and increased competitiveness in third markets through the liberalisation of EU export subsidies. Neither effect is large because the EU does not liberalise significantly. The LDC group makes significant gains, and this is again in part due to the minor nature of EU liberalisation, because the increase in food import prices that would lead to welfare losses does not materialise.

8.2.2 Agenda 2000

The welfare results from the Agenda 2000 scenario show that the EU will make small welfare gains from Agenda 2000 compared to the Uruguay Round scenario. It will become apparent from later tables that the main welfare effects of Agenda 2000 come from the reduction in intervention prices for beef (the Cattle, Sheep & Goats sector in this model), which reduces the need to purchase stocks to support the domestic market price, and the small (two percent) increase in milk quotas that allow a small reduction in the welfare costs of this quota.

The small welfare losses for the USA and Cairns Group from Agenda 2000 are a direct result of these reforms: the USA's exports of Cattle, Sheep & Goats fall because the EU no longer buys stocks to support the market price, allowing EU consumption to use these resources. The Cairns Group's exports of Milk and Milk Products decline as the EU quota increases.

8.2.3 CAP Removal

The CAP Removal scenario shows EU gains that are low in comparison to most estimates, but are similar to those in some recent studies (i.e. Harrison *et al.* 1995. Weyerbrock 1998). The equivalent variation of moving from the Uruguay Round without Agenda 2000 to complete removal of the CAP is $15.7bn (0.17% of GDP). With the Uruguay Round results being low in terms of EU equivalent variation because of the low level of EU liberalisation, it might be expected that the complete removal of the CAP would have a larger effect. When comparing the results of CAP removal in Table 8-1 with other studies, it must be noted that the CAP is characterised here as using compensation payments, set-aside payments and headage payments. Most other studies treat all CAP instruments as *ad valorem* output subsidies, which are less "removed from production". The benefit from removing a subsidy that is in part decoupled from production will be lower than the benefit of removing output subsidies. In this model, 49.2%) of EU domestic support is modelled as a decoupled or partially decoupled payment.

8.3 THE BASE CASE: PROJECTING THE WORLD ECONOMY FORWARD TO 2005

Table 8-2 shows some indicators of how the Base Case projections detailed in Chapter 6 affect the world economy. The equivalent variation in the Base Case is set by the GDP projection, and the USA aggregate price is the numéraire, as noted in Chapter 7. Aggregate prices are equivalent to GDP deflator inflation, and show higher aggregate prices in the EU than in the USA.

Market prices and output for agricultural goods are largely determined by three factors. Firstly, the factors of production used in agriculture (land, and unskilled labour[1]) become more scarce, which will lead to price increases. Secondly, low income elasticides of demand depress

[1] The scarcity of unskilled labour applies to the EU, where a small fall is projected for this factor. Outside the EU, factor growth is projected for unskilled labour.

Table 8-2: Base Case Summary

	UK	Germany	Rest EU	USA	Cairns	LDCs	ROW
EV ($bn)	223,454	469.622	953,696	2006.971	1495.768	1507.442	2365,886
(%)	22.86	22,86	22,86	30.91	63,42	69 1 1	34,78
Aggregate Prices	24,2(1	26.84	22.62	21.90	18.65	17.66	22,56
Market Prices							
Wheat	0.12	5,06	2.11	3.19	5,56	20,96	5,92
Other Grains	0.31	5,82	2.62	3,55	10.16	23.31	7,52
Vegetables & Fruit	2,99	5,09	4.36	4.23	10,20	23.61	7,84
Oil Seeds	-0.95	4,09	0,70	3,23	8,74	28,20	6,93
Sugar cane/beet	35.11	44,55	30,38	4.22	5,79	25,58	7,13
Other Agriculture	-0,77	2,40	1.44	1.08	10,30	18.01	3,36
Cattle. Sheep & Goats	-5,00	-4 90	-2,98	-10.69	4,35	14.25	-0,35
Other Livestock	-3,95	-1.19	-3,21	-1.21	1.84	12.76	0,40
Raw Milk	56,89	40,67	35,68	-5,89	0,64	15,22	-1,00
Cattle Meat	12,79	19.76	9,02	-4.12	6,24	7.76	9,05
Other Meat	13.14	17,74	8,55	6,33	6.18	7.32	7,75
Vegetable Oils	17.36	20. S3	15.58	10,09	10.46	15.22	16,43
Milk & Milk Prods	34,76	28,46	28,64	8,59	5,59	9.19	11.94
Sugar	21.87	25,03	25.82	12,65	6,45	14.01	15,35
Other Food	23,30	22.51	22.94	18.06	13.13	12.54	23,89
Other Primary	134.29	125,27	127.08	138,80	140.85	147 96	136,58
Manufactures	29.91	2S.49	28,91	27,23	23,25	20,74	27,63
Services	23,76	27.49	21.12	20,90	15.59	11.33	21.49
Output							
Wheat	9,54	7,64	12.86	29.88	27,23	20,99	13.21
Other Grains	12.16	0,86	1.78	6,00	20,89	21.46	10.81
Vegetables & Fruit	17.95	11.37	18.25	18.52	34.41	36,01	22,48
Oil Seeds	16.05	8,49	22,86	24,95	28,32	31.33	18,25
Sugar cane/beet	0,00	0,00	0,00	16.79	41,08	29,46	19.23
Other Agriculture	31.31	22,42	26,51	32,25	27,27	29,75	20,84
Cattle. Sheep & Goats	14,26	5,48	13.87	10,64	22,40	42,79	21,47
Other Livestock	10.62	6 99	17.40	15,66	35,72	55,26	26,84
Raw Milk	0,00	0,00	0,00	12.59	25,46	37.55	23,46
Cattle Meat	5,95	3,65	12,71	17.72	25,50	37,25	23,80
Other Meat	7,74	5,57	14.35	11.01	30,93	45,80	29,60
Vegetable Oils	9,54	1.56	11.14	15.17	34.27	40,82	17,24
Milk & Milk Prods	-0,15	-0,27	1.71	13.41	27,07	40,74	25,75
Sugar	3,00	1.70	1,80	11.87	36,95	39,96	18,46
Other Food	8,60	11.23	10,05	15,00	35,24	48.31	17,20
Other Primary	18.15	14,38	24,24	20,30	25.58	22,46	19,98
Manufactures	10,46	11.45	14.82	21.16	41.97	54,05	23.99
Services	20,10	14.60	22,47	27,39	49,30	57,88	31.04

agricultural prices as demand for agricultural products falls in relation to other goods. Thirdly, high productivity rates in agricultural sectors depress prices, and lead to the situation evident in many sectors in Table 8-2 of falling real prices and increasing output.

EU milk and sugar sectors are special cases, where the raw products are subject to quotas. This leads to real price increases in these sectors, and price increases above or only slightly under aggregate prices for the final sugar and milk produced products.

Cattle, Sheep & Goats in the UK is the only sector where the Base Case projections lead to intervention buying, with the price being supported at 5% below the 1995 market price. Chapter 6 discussed the intervention prices used in the model, and where the 1995 market price was above the intervention price a 5% difference was assumed, except for the cereals sectors where data on market price to intervention price ratios were available. The choice of a 5% difference between intervention price and market price is critical when determining whether the intervention price is reached or not: for the UK the price of Cattle, Sheep & Goats falls 5% to the intervention price and intervemion purchases are triggered, but in Germany the price falls by only 4.90% so that intervention purchases are not triggered.

8.4 DETAILED RESULTS IN THE AGRICULTURAL AND FOOD SECTORS

Tables 8-3 ,8-4 and 8-5 show details for market prices, quantities, and aggregate consumer prices; in each case the figures are percentage changes relative to the Base Case. The results are for the Uruguay Round, Agenda 2000 ('Ag') and CAP removal ("CAP"). (Market prices in Table 8-3 (and the Base Case prices in Table 8-2) refer to the market prices of domestic production.)

8.4.1 Price and output changes: quota-constrained agricultural sectors

For most products in the EU, market prices in the Uruguay Round scenario show fairly small changes for most products, with price increases of less than one percent and a few instances of small price falls (i.e. Wheat and Other Grains in the Rest of the EU). The exceptions to this rule are the quota-constrained products: Sugar Cane/Beet show price increases of 8.7%, 32.1% and 13.3% in the UK, Germany and Rest of EU respectively, and Raw Milk experiences price increases of 39.9%, 49.3% and 45.5%) - all from prices that were considerably higher than average prices in the Base Case. With factors mobile in these sectors, supply is quite elastic so that large increases in the *ad valorem* equivalent of the quota (and hence the price) are needed to restrict output when demand for these products rises. This happens partly because the 1995 export levels were considerably within Uruguay Round limits, allowing further exports of sugar and requiring only a small fall for milk to reach the constraints in 2005. Price rises in the Milk and Milk Products and Sugar sectors are considerably above rises in other sectors as a result of their higher intermediate input costs.

Output of the processed milk and sugar goods increases in the Uruguay Round in each EU region despite the quotas on the raw products, and the milk sector is able to do so only by purchasing raw products that were previously used in other sectors - raw sugar, unlike raw milk, is traded so that the Sugar sector is able to purchase more imports of Sugar cane/beet.

For all the quota-constrained goods and their processed products, prices fall under Agenda 2000, with the falls for Raw Milk and Milk and Milk Products being larger as a result of the quota increase. Prices for these goods fall dramatically with the removal of the CAP, with small **output** falls (these sectors also benefit from CAP subsidies). Sugar cane/beet output falls by 12.9% **with** CAP removal.

8.4.2 Price and output changes: other agricultural and food sectors

Price and output effects in sectors that are not directly affected by the CAP quantity constraints are generally small as a result of the Uruguay Round and Agenda 2000, with significant output falls after the removal of the CAP.

The Cattle. Sheep & Goats sector in the UK is a special case because intervention prices were binding in the Base Case. In this sector, prices remain constant at the Base Case level during the Uruguay Round simulation because this is the intervention price; upon the 30% reduction in intervention prices for this sector in Agenda 2000, a small price fall of 3.3% occurs. There are no intervention purchases to support the domestic market price in the Agenda 2000 scenario. **Output** falls to 11.9% below the Base Case level in Agenda 2000 because of lower prices.

Other agricultural sectors have two main forces acting upon them. Firstly, the general but small fall in EU welfare in **the** Uruguay Round scenario, and subsequent rises in the Agenda 2000 and CAP removal scenarios, will have both negative and positive effects on demand for all products. Secondly, competition between sectors for **inputs will** tend to raise prices as a result of Milk **and** Milk Products expansion in the first two scenarios, and the fall in output of Cattle, Sheep &

Table 8-3 Changes in Market Prices Relative to Base Case (per cent)

	UK			Germany			Rest of EU			USA			Cairns Group			LDCs			Rest of World		
	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP
Wheat	0.2	-1.2	-1.1	0,1	-1,2	-1.3	-0.4	-1,5	-2,4	5,3	5,3	7,3	2,2	2.1	[illegible]	1,9	1,9	2,6	[illegible]	1.1	2,2
Other Grains	0,1	-1,4	-1.5	0,3	-0.8	-0,7	-0,4	-1.4	-1,9	3.1	3,0	5.1	-0.1	-0,2	1,9	2,4	2,4	3,2	-0,2	-0.2	1.0
Vegetables & Fruit	-0.1	-0.9	-3,7	-0,1	-0,1	2,6	-0,3	-0,2	-2,3	0,9	[illegible]	3.0	-0,8	-0,9	1,2	0,6	0,6	1,3	-1.6	-1.6	-0,5
Oil Seeds	0,0	-0,6	34,7	-0,1	-0,2	30,8	-0.1	[illegible]	36,9	2,9	2,9	5,0	0,4	[illegible]	2,3	1.6	1,5	2,5	0,8	0.8	2.1
Sugar cane/beet	8,7	9.8	-57.2	32.1	41,4	-58,5	13.3	14.1	-54,2	3.3	3.3	6,1	-0,3	-0,4	1.4	1,5	1.4	2,3	1,9	[illegible]	3,0
Other Agriculture	-0,1	-0,9	-0,3	0,1	0.0	2,3	-0,2	-0,1	[illegible]	1,4	1,3	3,5	-0.8	-0,9	1,5	0,8	0,8	1.6	1.2	[illegible]	2,5
Cattle, Sheep & Goats	0.0	-3.3	5,3	0,0	-0.4	9,9	3.9	0,7	-3,1	3,1	3,1	[illegible]	0,2	0,2	2,1	1,0	0,9	1.8	0,3	0.3	1.1
Other Livestock	0.4	-0,6	5,9	0,7	0.4	7,1	0,8	0.1	5.8	[illegible]	1.9	3.3	[illegible]	0,1	1.9	0,8	0,8	1,6	[illegible]	-06	0.1
Raw Milk	39.9	7,1	-59,8	49,3	12,7	-52,6	45,5	15.3	-52,6	2,7	2,6	4,3	0,3	0,3	1.8	0,9	0,8	1.7	2,1	2,1	3.1
Cattle Meal	0,3	-0,5	3,0	0,6	0,4	-0,3	1,9	0,4	-5,2	[illegible]	2.2	3,4	-0,1	-0,1	1.1	0.9	0,8	1.4	-0,1	-0,2	0,5
Other Meat	0,4	-0,5	3,1	0,6	0,4	-0,2	0,7	0,3	2.7	1,2	1.2	1.9	-0.1	-0,1	[illegible]	0.8	0.8	1.4	-0,2	-0,2	0,3
Vegetable Oils	0,7	0,2	5.7	1.9	[illegible]	-1,7	0,9	0,6	4,3	1,3	1,3	2,3	-0,6	-0,7	0,3	1,0	0,9	1.5	-2,1	-2,1	-1,4
Milk & Milk Prods	17,8	3,4	-25,6	19,5	5,3	-20,8	19,9	6.8	-22.8	[illegible]	[illegible]	1.8	0.1	0.1	[illegible]	0,8	0,8	1.3	[illegible]	[illegible]	1.9
Sugar	2,6	2,9	-19,9	7,3	8,0	-12,3	4,6	4.9	-20,3	1.2	1,2	2,3	-0,3	[illegible]	0,9	1,0	[illegible]	1,4	-0,3	-0,4	0,5
Other Food	1,2	0,3	-3.8	1,6	1.0	-1,0	0,5	0,2	-2,1	0.3	0,3	0.5	-0,5	-0,5	0,2	0,9	0,9	1,2	-1.3	-1,3	[illegible]
Other Primary	0,3	0.3	0,0	0,2	0,3	-0,2	0,2	0,2	-0,2	0,1	0,2	-0,3	0,2	0,2	-0,3	0,2	[illegible]	-0,2	0,4	0,5	0,0
Manufactures	-0,2	-0,1	-0,5	-0,1	0,0	-0,4	-0.1	-0,1	-0,6	0.0	0,0	-0.1	-0,6	-0,6	-0,5	0,4	0,4	0,4	0,4	0.4	0,3
Services	0.0	0.0	-0,5	0,0	0.1	-0.4	0,0	0,0	-06	0.0	0.0	0,0	-0,2	-0,2	0.1	0,4	0,4	0.5	[illegible]	0,5	0,5

Note: UR = Uruguay Round. Ag = Agenda 2000, CAP = CAP abolition

Table 8.4: Changes in Output Relative to Base Case (per cent)

	UK			Germany			Rest of EU			USA			Cairns Group			LDCs			Rest of World		
	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP
Wheat	-3.1	-2.3	-6,3	-3,0	-2,3	-7.1	-4,1	-3.1	-6,6	1.6	[illegible]	0,8	2,4	2,2	3,2	1.1	1,0	1,2	-26,0	-26,0	-25,1
Other Grains	-4.1	-3,2	-22.8	-4.2	-3.5	-25,9	-2,6	-1,9	-22,8	5,0	4,9	8,9	-5,9	-6,0	-3,9	0,4	0,4	1,0	-35,7	-35,8	-34,0
Vegetables & Fruit	0,0	0,7	1.9	-0,6	-0,4	-5,2	0,4	0,3	0.2	-1.0	-1.0	-1,6	0,1	0,1	-0,6	-0,2	-0,2	-0,2	1.0	1,0	0,7
Oil Seeds	2.4	3.7	-14,2	4,3	5,0	-27,2	5,6	5,2	-40,0	-2,0	-2,0	1.8	0.7	0,7	3,1	-0,2	-0,2	[illegible]	-7.6	-7,6	-3,5
Sugar cane/beet	0,0	0,0	2,3	0,0	0,0	-0,4	0,0	0,0	-12,9	-5,7	-5,7	-6,0	2,0	2,1	[illegible]	-0,2	-0,2	0.0	-7,8	-7,8	-5,7
Other Agriculture	0.6	2,1	-2,1	1,2	1,5	-9,7	-0.2	-0.4	-6,0	-0,3	-0.3	0.7	0,2	0,2	-1.0	-0,2	-0,2	[illegible]	0.0	0.0	[illegible]
Cattle, Sheep & Goats	-3,2	-11,9	-30,9	-2,6	-3,5	-28,9	-4,6	-3,2	-37,0	1,2	[illegible]	6,5	0.6	0,5	10,1	0,6	0,6	1,5	-1.9	-1.9	5.2
Other Livestock	-1,2	-0.7	-9,3	-0,3	-0,2	-3,4	-0.7	-0,3	-4,9	1,9	1,9	2,8	-4,1	-4,1	-3,7	0,7	0,7	0.6	-0.2	-0,2	0,2
Raw Milk	0,0	2,0	0,5	0.0	2,0	-1,4	0,0	2,0	[illegible]	-1.2	-1.3	-0,8	-1.2	-2,5	6,3	0,2	0,2	0,5	-1,7	-2,0	-0,7
Cattle Meat	0,7	0,9	-25,3	2,9	2,8	-8,4	-1,9	-1,0	-21,9	[illegible]	2,1	6,4	5,9	[illegible]	[illegible]	5,2	5,2	8,0	-2,7	-2,7	-2.4
Other Meat	1.1	1,5	-1.0	2,9	2,9	2,8	0,1	0,3	-3,1	3,0	2,9	3,4	-3,4	-3,4	-3.6	7.6	7,5	8,2	0,4	0,4	0,7
Vegetable Oils	1.9	2,7	-3,4	2,3	2,7	[illegible]	2,0	2.3	-2.7	1.2	[illegible]	1.4	4.9	4,8	[illegible]	3,8	3,7	4.0	-4,4	-4,4	[illegible]
Milk & Milk Prods	1,3	3,9	-1,4	2.8	5.0	0.1	0,8	2,8	-1.9	-0,2	-0,3	0,2	3,0	[illegible]	13,6	7,9	7,0	11.9	[illegible]	-2,7	-0,2
Sugar	2,0	2,2	-28,9	1.4	1.4	-1.6	[illegible]	2,2	-20,5	-3,0	-3,0	-2,8	6,5	6,6	9.5	4.7	4,7	8.1	-5.6	-5,6	[illegible]
Other Food	0,7	1,5	3,3	1.1	1.6	[illegible]	[illegible]	0,3	-1.1	2,0	1.9	2,0	2.1	[illegible]	2,2	4,8	4,7	5,5	[illegible]	[illegible]	[illegible]
Other Primary	0,6	0,6	0,6	2,5	2,5	2,5	[illegible]	0.1	0,1	1.4	1.4	1,3	4.7	4,7	4.6	4,5	4,5	4.4	0.2	[illegible]	0.1
Manufactures	0,4	0,3	0,7	2,5	2,4	2,8	[illegible]	-0,2	0,7	[illegible]	1.1	1,0	[illegible]	4,9	4,2	4,3	4,3	4,0	0.5	0.5	0,4
Services	0,6	0,6	0,7	2,4	2,4	2,4	[illegible]	0.1	0.2	1.4	1,4	1.4	4,7	4,7	4,7	4,5	4.5	4.5	0.1	0.1	0,1

Table 8 -5: Changes in Aggregate Consumer Prices Relative to Base Case (per cent)

	UK			Germany			Rest of FAI			USA			Cairns Group			LDCs			ROW		
	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP
Wheat	0.5	-0.7	-2,1	0,0	-1,2	-2,2	-0,1	-1,2	-2,5	[illegible]	[illegible]	5.1	[illegible]	-3,8	-2,2	4,4	[illegible]	5,3	-14,9	-14,9	-13,7
Other grains	-0.1	-1.2	-5,4	0,0	-0,9	-4,4	0,0	-0,8	-7,3	2,1	2,1	4,5	-12,5	-12.6	-10,8	[illegible]	[illegible]	4,7	-18.6	-18.7	-17.4
Vegetables, fruit & nuts	-0,1	-0.5	[illegible]	-02	-0,1	0,0	-0,2	-0,2	-2,5	0,5	0,4	1.9	-0,9	-1,0	0,8	-0,8	-0,9	-0,2	-1.4	-1,4	-0,7
Oil Seeds	1.1	0,8	[illegible]	0,8	0,8	21,5	0,7	0,9	22,1	1,9	1.9	4.0	0.3	0.2	2,0	1,7	[illegible]	3,7	1,2	1.2	3.2
Sugar Cane& Beet	5.2	[illegible]	-49,9	24.1	29,3	-49,4	[illegible]	9,0	-49.6	1.8	1.8	3,9	0,0	-0.1	1,5	2,4	2,4	3,4	-0,2	-0,3	[illegible]
Other Agriculture	0,2	-0,2	-2.0	0,2	0,2	00	0,0	0.0	-3,4	[illegible]	0,7	[illegible]	-1.7	-1,7	0,3	0,3	0.2	1.4	[illegible]	0.5	1.9
Cattle, Sheep & Goats	-0,3	-2,4	-20,8	[illegible]	[illegible]	-11.8	3.4	0.7	-16,4	19	1,9	4,0	-1 5	-1,6	0,5	7,7	7,5	12.9	4.5	4,3	10.5
Other Livestock	1.8	[illegible]	6,5	1.7	[illegible]	7,0	[illegible]	[illegible]	6.7	4,3	4,2	6.1	-2.3	-2.4	[illegible]	3.5	3.4	[illegible]	2,8	2,7	4,5
Raw Milk	39,9	7,1	-59,8	49,3	12,7	-52,6	45,5	15.3	-526	2,7	[illegible]	4,3	0,3	0,3	1.8	[illegible]	0,8	1.7	2,1	2.1	3.1
Cattle Meat	0,4	-0,2	-20,9	0,0	-0,4	-20,4	1.1	0,0	-19.8	1.3	1.3	2,5	-4,3	-4,4	-3.1	2,7	2,7	6,7	-4,5	-4,6	-2,9
Other Meat	1.1	0,4	3,0	2,0	1,7	[illegible]	[illegible]	1.2	2.7	4.1	4.0	[illegible]	-0,4	-0.5	0,9	6,9	6,9	8,2	-0,5	-0,6	0,4
Vegetable Oils	0.7	0.4	4,2	[illegible]	0,8	0,6	0.8	0,5	3,2	0,6	0,6	[illegible]	-1.5	-1,5	-0,5	0,6	0,5	1,3	-3,3	-3,4	-2,4
Milk Products	16,0	5,3	[illegible]	20,5	7,2	-20,6	20,1	7,3	-21.6	9,2	5,5	26,0	4,8	3.8	10,4	8,6	6,7	17,6	7.1	5,1	17.0
Sugar	2.7	2,8	-29,9	5,7	6,1	-21,8	4,2	4,4	-25,5	0,8	0,7	1,8	-0,6	-0,7	0.8	0,8	0,8	2,5	-5,7	-5,7	-2,5
Other Food	0,8	0,3	-4,4	0,9	0,5	-2,7	0.5	0,2	-3,5	0,3	0,3	0,2	-1.1	-1.1	-0,9	1,3	1.3	[illegible]	-1.7	-1.8	-1.8
Primary	0,3	0,3	-0,1	0,2	0,3	-0,2	0,2	0,2	-0.2	0,2	0,2	-0,2	-0.3	-0,3	-0,7	0,0	0,1	-0.4	0.2	0,3	-0,2
Manufactures	-0,4	-0,4	-0,7	-0,4	-0,3	-0,7	-0,3	[illegible]	-0,7	-0,4	-0,4	-0.5	-1.5	-1.5	-1,5	-0,5	-0,5	[illegible]	0.0	0.0	[illegible]
Services	0,1	0.1	-0,3	0.1	0,1	-0,3	0,0	0,1	-0,4	0,1	0,1	[illegible]	0,0	0.0	[illegible]	0,3	0,3	[illegible]	0,4	0.4	0.3

Goats. Sectors that compete with these sectors for both factors of production and intermediate inputs will experience general equilibrium effects. The changes in aggregate consumer prices reported in Table 8-5 reflect changes in the prices of domestic and imported goods. They are presented here for completeness, but the analysis of their impact on consumers is carried out subsequently in terms of changes in consumer welfare

8.4.3 Changes in EU exports and imports

Table 8-6 reports changes in aggregate exports for commodities, again as a percentage relative to the Base Case. Table 8-7 reports changes in intra-EU exports and extra-EU exports separately. Aggregate imports are reported in Table 8-8, with Table 8-9 covering intra- and extra-EU imports. The discussion below focuses on sectors where there are significant proportional changes in aggregate exports and imports.

EU exports

Changes in a sector's exports tend to be of the same sign but in greater proportion than changes in sectoral output, a common feature in open economy models, and reflecting the same causes. The notable reductions in exports for the EU are in Wheat and Other Grains. Cattle. Sheep and Goats and Other Livestock under all three scenarios, with CAP abolition showing the largest falls for all these sectors. Oil Seed exports rise throughout the EU under the UR and Agenda 2000 scenarios, but fall sharply upon CAP abolition. Sugar Cane/Beet exports rise marginally for the UK, markedly for Germany but fall for the rest of the EU under the UR and Agenda 2000 regimes, but increase dramatically upon CAP abolition. Sugar exports changes marginally for all EU countries/regions under UR and Agenda 2000, but fall markedly with removal of the CAP. Exports of Milk and Milk Products by all EU countries rise above the Base Case levels after implementation of the UR commitments and of Agenda 2000, but CAP removal reduces the UK expansion substantially and reduces exports by the others to below the Base Case levels.

*EU **imports***

Implementation of the UR commitments and of Agenda 2000 result in few significant changes in imports, save for rise in Sugar Cane/Beet imports by Germany and the rest of the EU, and a fall in imports of Cattle, Sheep and Goats by Germany. CAP abolition leads to very large increases in imports of Cattle, Sheep and Goats and Cattle Meat by the UK and Germany and to a lesser extent by the rest of the EU, and to large increase in imports of Sugar throughout the EU, but to roughly equivalent falls in Sugar imports by Germany and the rest of the EU.

Table 8-6: Changes in Aggregate Exports Relative to Base Case (per cent)

	UK			Germany			Rest of EU			USA			Cairns Group			LDCs			Rest of World		
	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP
Wheat	-10,5	-8,6	-14,6	-11.8	-10,3	-17,6	-10.0	-8,4	-9,1	2,8	2,4	1,2	19.1	18,7	19.5	2,7	[illegible]	10.5	-27,2	-27,9	-22,9
Other Grains	-15,3	-13.3	-53,4	-21.6	-20,9	-60,9	-8,3	-7,6	-42,8	20,6	20.4	29.8	7.0	6.8	19.3	32,2	31.9	46,7	-49,4	-49,9	-25,0
Vegetables & Fruit	-0,6	2,8	7.7	-0.3	-0,2	-16,9	0,9	0,7	0,9	-4,6	-4.4	-6,0	4,4	4,7	3,2	-1.3	-1,2	3,2	4,8	5,0	7,9
Oil Seeds	[illegible]	12,3	-60,0	9.6	10,5	-53,1	9,7	8.5	-60.3	-4,8	-4,6	4,3	5,2	5,7	19,0	4,3	4,3	15.6	-18.4	-18.2	-1,4
Sugar cane/beet	4,7	0,5	272,1	48,8	41.9	254,0	-22,2	-24,7	84,0	-49,3	-49,3	-51.0	3,7	3.8	1.5	-4,4	-4,0	-13.3	-36,2	-36,2	-35.2
Other Agriculture	1,4	4,5	-4,2	3,1	3.3	-14,5	-1,0	-1,4	-10,4	-0.1	-0,1	3.4	6,3	6,6	0,6	-0,3	-0.4	3.3	-5.8	-5,8	24,7
Cattle, Sheep & Goats	-12,2	-8,6	-90,7	-13,1	-19.4	-92.9	-16.8	-13.3	-81,4	26,8	23,7	178.1	8,8	8,7	20,8	19.0	18,3	48,8	-26.8	-26,8	167.6
Other Livestock	-11,7	-9.7	-22,0	-7,9	-8.5	-23,7	-6,2	-5,5	-13.3	6,8	6,4	11.2	-12,8	-13,0	-9,8	28,0	27,1	43,4	-33.7	-33.7	-33.7
Callle Meal	-1,2	-1,2	-81,6	1,3	-0,6	-81.1	-9,1	-6,3	-76,5	6,4	6,0	39,8	14,5	13,7	108.9	17.2	18.5	90.6	-26,8	-26,8	-26.8
Other Meat	4,7	6,4	-8,7	6,0	5,3	5,9	-0,4	0,1	-7,0	21,7	21,3	26,6	-40,8	**-40,8**	-40,8	[illegible]	42,7	59,1	2,4	2,0	11,3
Vegetable Oils	8.1	9,6	-7.9	9,6	12,9	34.3	7,9	8,5	-1,5	-3,1	-3.3	-3,2	1,6	1,3	1,9	-4,8	-5,2	-1.5	-31.4	-31,4	-31.4
Milk & Milk Prods	15,4	26,5	3,7	6.1	13,4	-18.1	3,7	9,4	-13,0	-49,4	-49,4	-48,2	-13,7	-23,5	43,1	52,5	34.4	173.0	-49,1	-49,1	-49.1
Sugar	1.3	1,0	-56,3	-2,0	-3,1	-71.8	1.3	1,2	-48,9	-42,2	-42,2	-39,8	11,3	11.5	24,6	6,4	6,9	50.6	-34,5	-34,5	-30.4
Other Food	4,4	7,8	18,7	-3,2	-1,3	-6,1	1,5	1.8	-0,9	10.9	10.4	12,2	-12.3	-12,6	-10,1	3,0	2.5	11.9	10.9	10.3	16.2
Other Primary	0,2	0,2	-0.1	[illegible]	0,2	0,6	0.1	0,0	0,0	0,6	0,6	0,6	[illegible]	[illegible]	1.2	0,7	0.7	0.8	0.1	0.1	0.1
Manufactures	0.6	0.4	1.3	1.1	[illegible]	2.0	0.3	0.2	1.8	[illegible]	[illegible]	0.4	5,3	5,4	3.8	3,7	3.7	3.0	3,1	3.1	2.7
Services	0.6	0.6	2,0	0,4	0,4	1,3	0.6	0,6	[illegible]	0.5	0,5	-0.2	1,4	1.5	-0,1	-1.0	-0.9	-1,7	-1.3	-1,3	-1,6

Table 8-7: Changes in Extra-EU and Intra-EU Exports (fob) Relative to Base Case (per cent)

	Extra-EU Exports												Intra-EU Exports (fob)											
	UK			Germany			Rest of EU			EU Total			UK			Germany			Rest of EU			EU Total		
	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP
Wheat	-34	-31.2	-31.0	-29.3	-26.9	-33.[illegible]	-24.1	-[illegible]2.2	-17.[illegible]	-25.6	-22.8	-2[illegible].5	-0.5	[illegible]	-76	0.2	1.0	-6.7	[illegible].9	2.5	-2.3	1.3	2.0	-3.8
Other Grains	-50.9	-50.9	-81.2	-44.2	-44.2	-78.3	-56.2	-56.2	-77.2	-51.[illegible]	-5[illegible].1	-78.[illegible]	[illegible].3	4.3	-40.3	0.7	2[illegible]	-43.8	2.7	3.6	-39	[illegible].3	3.4	-36.[illegible]
Vegetables & Fruit	-0.8	2.4	18.2	1.1	0[illegible]	6.2	4.8	4.2	16.3	4.5	4.0	15.5	-0.6	2.9	4.1	-0.6	-0.4	[illegible].2	[illegible]	0.0	-2.2	0[illegible]	[illegible].0	-2.7
Oil Seeds	1[illegible].5	13.6	-64.7	14.4	14.9	-59.3	14[illegible]	[illegible]3.3	-65.9	14.0	[illegible]2.6	-6[illegible].3	8.5	[illegible].5	-5[illegible].2	89	9.9	-52.3	8.5	7.4	-58.6	86	8[illegible]	-57.6
Sugar cane/beet	5.3	10	28[illegible].4	60.0	53.4	266[illegible]	-21.2	-34.5	9[illegible].5	-4.4	-8.3	146	-7.6	40.2	90.0	-6[illegible].2	-70.8	1[illegible]9	-4[illegible].5	-25.4	6[illegible].2	-26.0	-27.4	72.9
Other Agriculture	-43.7	-43.7	9[illegible]6.5	-47.6	-47.6	-97.7	-53.9	-53.9	-95.3	-50.3	-50.3	-[illegible].2	[illegible].0	4.3	-19[illegible]	[illegible].2	0.5	-27.7	[illegible].8	1.4	[illegible]49	1.6	1.5	-16.3
Cattle, S & G	-4[illegible].5	-4[illegible].8	-55.9	-36.3	-36.2	-58.2	-41.9	-4[illegible].6	-55.3	-40.9	-4[illegible].5	-55.9	6.6	23.5	-85.4	166	4.9	-88.8	-5.8	-1.3	-77.3	-0.7	[illegible].6	-79.7
Other Livestock	-226	-2[illegible]	-93.0	6.9	8.9	9[illegible]4.5	-27.7	-[illegible].3	-92.3	-22.4	-[illegible]2.9	-92.6	[illegible].8	14.9	4.9	10.3	9[illegible]	[illegible].6	9.2	10.0	4.7	9.5	10.4	3.9
Cattle Meat	-12.0	-1[illegible].6	-33.0	56	56	[illegible]8.3	-23.6	-22.5	[illegible]27.3	-2[illegible]6	-20.6	-27.[illegible]	0.8	0.7	-8[illegible].5	-[illegible].2	-3.0	-77.8	-6.2	-31	-741	-4.6	-2.5	-75.3
Other Meat	2[illegible].0	33.0	2.5	24.5	28.4	50.9	19.9	20.9	8.8	[illegible].8	23.3	6.2	8.7	10.7	-2.9	61	5.3	11.6	6.6	6.9	30.9	6.7	6.9	-0.2
Vegetable Oils	271	491	-65.3	5.5	23.8	-73.7	6.3	24.7	-70.0	7.2	25.7	-70.4	06	[illegible]9	-14.0	-4.9	-3.2	182	-[illegible]4	0.8	-8.5	-0.9	-0.[illegible]	-5.1
Milk & Milk Prods	-3.7	-4.2	-69.2	7.5	6.8	83.[illegible]	6.6	5.9	68.5	5.7	5.0	71.8	19	20.3	22.9	6.2	[illegible]6	-9[illegible]	3.0	5.3	21	4.1	7.5	0.3
Sugar	12.6	16.6	[illegible]	0.5	2.8	[illegible].7	4.8	5.7	17.2	5.5	71	20.4	7.2	7.[illegible]	-4[illegible].3	[illegible].5	-13.1	-4[illegible].3	-1[illegible].3	-11	-39.7	-2.1	-2.2	-424
Other Food	[illegible].8	4.7	9.2	7.2	7.4	4.4	-7.0	-7.6	-0.5	-4.2	-4.3	1.[illegible]	-3.2	-0.4	-2.[illegible]	-5.0	-3.4	[illegible]5.3	0.1	0.0	-9.4	-1.[illegible]	-4.5	-9.6
Other Primary	0.9	0.9	0.3	[illegible].3	[illegible].3	[illegible]	-0.2	-0.2	-06	0.2	0.2	-0.2	0.4	-0.4	0.3	0.1	-0.	0.4	[illegible].3	0.3	0.5	0.[illegible]	0.[illegible]	0.2
Manufactures	3.2	2.9	4.7	5[illegible]	5.0	6.8	4.2	4[illegible]	6.6	4.4	4.2	6.4	[illegible]4	[illegible].6	-1.3	-2.1	-2.1	-1.8	-1.9	-1.9	-0[illegible]	-1.[illegible]	-2[illegible]	-1.2
Services	0.8	0.7	2.5	0.7	0.7	2.2	0.9	0.9	2.8	[illegible].9	0.8	2.7	0.3	0.2	[illegible].7	[illegible]	0.0	[illegible].3	[illegible].3	0.3	1.[illegible]	0.3	0.2	0.9

Table 8-8: Changes in Aggregate Imports Relative to Base Case (per cent)

	UK			Germany			Rest of EU			USA			Cairns Group			LDCs			Rest of World		
	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP
Wheat	-0,7	-0,9	0,0	0,0	[illegible]	0,7	-0,9	[illegible]	-0.6	9.2	9.2	10.1	13,4	13.4	13,6	-6,7	-6,4	-6,6	37,7	37.7	37,0
Other Grains	0,2	-0,1	5.1	0,2	[illegible]	7,4	-0,6	-0.5	7.0	4.4	4,4	5.4	40.9	40,8	41.4	-2,9	-2.9	-4,2	23,9	23,9	23,5
Vegetables & Fruit	0,0	-0.1	-2,3	0.0	0,2	2.2	0,0	0.1	0,7	0,7	0,7	1.5	[illegible]	0,2	0.6	6,0	6,0	6,0	0,0	-0.1	1,0
Oil Seeds	-1.3	-1,3	5,9	-1,0	-0,7	4.0	1.3	[illegible]	7,6	2,5	2,5	2,7	0,4	0,3	0.4	-0,8	-0,8	-5,0	-3.5	-3,5	-4,4
Sugar cane/beet	2,1	2,8	-3,4	26,3	43,1	-43,8	23,2	24,9	-42,7	0.5	0,4	1.9	-0,2	-0,2	1.6	-3,6	-3,6	-2,5	1,5	1.5	3,0
Other Agriculture	-0,3	-0,5	-0,4	-0,2	0,0	0,6	-0,4	-0,3	5,1	1.4	1.4	2.2	2,6	2,5	3,6	2.1	[illegible]	0,7	[illegible]	1,2	1.0
Cattle, Sheep & Goats	0,7	-2,2	214.2	-13,5	-9,1	187.2	-1,2	-1,7	40,6	7,3	7,3	8.9	8,7	8,6	[illegible]	-28,8	-28,4	-41,2	-16,1	-15.6	-30.8
Other Livestock	-4,4	-5,0	-4,7	-3,7	-2,8	-2,4	-3,5	-3,5	-5,0	-6,5	-6,5	-7,4	10,4	10.4	[illegible]	-13.7	-13.4	-16.4	-10.4	-10.4	-13.3
Cattle Meat	-0,2	-0,3	81,7	1,3	1.9	113.6	0,7	0,5	47,0	2.1	2.1	2,1	16.8	[illegible]	19,8	-5,7	-5,6	-14.5	[illegible]	11.2	8,0
Other Meat	-1,4	-1,4	-0,8	-3,2	-2,9	-4.1	-2,3	-2.2	-1.3	-4,7	-4,7	-7,2	0,0	0,0	-0.9	-17.0	-16.8	-18.5	[illegible]	1.2	0,0
Vegetable Oils	0,0	0.3	2.5	2,5	[illegible]	-9,2	0,4	0,5	0,3	2,1	2,2	1,6	2,4	2,4	2,3	[illegible]	[illegible]	0,3	3,4	3,6	2,9
Milk & Milk Prods	1,9	-3,6	32,1	-3,4	[illegible]	2,4	-3,0	-1,5	0,8	-16.7	-10,2	-34,6	-10,7	-9,2	-17,0	-15,3	-12.2	-26,9	-13,8	-10.2	-28,2
Sugar	0,2	1.1	30,0	4,3	5,5	50,5	1,2	1.6	21.6	0,3	0,3	0,6	0,5	0,4	-0,6	0,6	0,6	[illegible]	[illegible]	[illegible]	[illegible]
Other Food	0,6	0,2	3,2	1,3	[illegible]	[illegible]	-0,2	0.0	4.1	-0.1	0,0	0,9	1,7	[illegible]	3,8	-1,6	-1,4	0,4	2,3	2,5	3,6
Other Primary	-0,1	-0.1	0,3	0,0	0,0	0,2	-0,2	-0,2	0,3	-0,3	-0,3	-0.5	2,1	2,2	1.6	0.8	0,8	0,6	0,9	[illegible]	0.8
Manufactures	LO	1.0	0,9	1,5	1,5	1.4	0,7	0,7	0.6	2,0	2,0	2.1	4,5	4,4	4,7	4,2	4,1	4,4	2,3	2.3	2,4
Services	-0,3	-0,3	-0.9	-0,2	-0,2	-0,5	-0,2	-0,2	-0,7	-0,3	-0,3	0,2	-0.7	-0.7	0,1	0,5	0,5	1.0	0,7	0.7	0,8

Table 8 – 9: Changes in Extra-EU and Intra-EU Imports Relative to Base Case (per cent)

	Extra-EU Imports											
	UK			Germany			Rest of EU			EU Total		
	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP
Wheat	-13.[illegible]	-16.5	14.8	-5.5	-9.[illegible]	33.3	-14.[illegible]	-17.7	8.7	-13.4	7.0	19.4
Other Grains	-3.3	-6.7	209.3	-4.0	-7.2	237.6	-7.7	[illegible]	30.4	-7.3	0.0	139.6
Vegetables & Fruit	-0.9	-0.5	4.8	0.3	1	11.2	0.1	0.5	8.2	0.0	0.5	8.3
Oil Seeds	-6.8	-6.5	[illegible]	-5.7	-4.8	42.5	[illegible]	[illegible]	220	[illegible]	-0.7	25.8
Sugar cane/beet	2.4	31	4.1	2.0	431	-546	25.9	27.8	[illegible]	[illegible]	1.2	7.9
Other Agriculture	[illegible]	26	376.4	-30.9	-32.4	6039	-3.2	[illegible]	581	-31	0.7	[illegible]
Cattle, Sheep & Goats	-32.3	-34.2	-20.0	-35.0	-35.9	[illegible]	-35.2	[illegible]	-25.3	-35.0	-36.3	[illegible]
Other Livestock	2.4	0.9	51.3	9.7	7.6	[illegible]	[illegible]	6.4	372.9	8.8	5.2	[illegible]
Cattle Meat	-55.3	-55.8	-16.9	-55	-55.7	-18	-48.8	-49.5	-5	-52.0	-52.6	[illegible]
Other Meat	0.6	0.2	9.0	4.2	[illegible]	-0.4	2.2	[illegible]	4.8	2.2	1.6	4.8
Vegetable Oils	22.0	9.8	71.3	-69.4	-746	[illegible]	-59.4	-67.6	4.5	-53.3	-49.0	551
Milk & Milk Prods	[illegible]	[illegible]	41.0	7.4	9.4	174.2	7.7	8.9	[illegible]	4.4	5.6	96.0
Sugar	2.8	[illegible]	[illegible]	4.6	3.4	39.5	2.3	[illegible]	[illegible]	2.7	1.7	32.5
Other Food	-19	[illegible]	7.6	[illegible]	-1.3	7.2	-1	-0.9	306	-1.4	[illegible]	[illegible]
Other Primary	-0.2	-0.2	[illegible]	-0.2	-0.3	[illegible]	-0.2	-0.2	[illegible]	-0.2	-0.2	0.3
Manufactures	4.7	5.8	4.1	5.8	5.9	4.3	6.2	6.3	[illegible]	6.0	6	4.3
Services	-0.7	[illegible]	[illegible]	-0.8	-0.7	-2.2	-0.7	[illegible]	-2.2	0.7	-0.7	-2.2

	Intra-EU Imports											
	UK			Germany			Rest of EU			EU Total		
	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP
Wheat	3.8	4	-5	0.7	[illegible]	-3.6	1.3	[illegible]	-3.8	1.3	[illegible]	-3.8
Other Grains	0.8	1.1	-25.3	0.8	[illegible]	-19.5	2.8	[illegible]	[illegible]	2.3	[illegible]	[illegible]
Vegetables & Fruit	0.5	[illegible]	[illegible]	-0	0.0	-0.6	0	0.0	[illegible]	0.1	0.0	[illegible]
Oil Seeds	8.7	7.9	[illegible]	7.4	6.6	-54.9	9	8.6	[illegible]	8.6	[illegible]	-576
Sugar cane/beet	[illegible]	-38.8	[illegible]	35.2	[illegible]	[illegible]	[illegible]	-27.4	[illegible]	-26.0	-27.4	72.7
Other Agriculture	[illegible]	[illegible]	-14.6	[illegible]	[illegible]	-7.7	1.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cattle, Sheep & Goats	[illegible]	-13.1	[illegible]	[illegible]	10.9	[illegible]	-0.2	[illegible]	-80	-0.7	[illegible]	-79.7
Other Livestock	9.0	9.1	2.9	7.6	91	4.5	[illegible]	10.9	[illegible]	9.5	[illegible]	[illegible]
Cattle Meat	-5.7	-1.4	[illegible]	-8.5	[illegible]	-76.8	[illegible]	-2.2	[illegible]	[illegible]	-2.5	-75.3
Other Meat	3.3	3.3	[illegible]	9.7	10.2	[illegible]	5.9	6.2	[illegible]	6.7	6.9	-0.2
Vegetable Oils	-0.3	0.4	-2.3	[illegible]	0.7	[illegible]	[illegible]	-0.5	-4.2	-0.9	-0.3	-51
Milk & Milk Prods	[illegible]	[illegible]	[illegible]	7.	8.1	[illegible]	5	7.8	3.2	[illegible]	7.5	[illegible]
Sugar	-75	-7.7	-67.2	2.4	31	-27.8	-2.5	-2.6	[illegible]	[illegible]	-2.2	[illegible]
Other Food	-0.7	[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]	-0.8	[illegible]	-1.1	-0.5	-9.6
Other Primary	0.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-0.1	-0	0.2	0.0	0.0	0.3
Manufactures	-2.7	-2.8	[illegible]	[illegible]	[illegible]	-1	-1.7	[illegible]	[illegible]	-1.9	[illegible]	-1.2
Services	0.3	[illegible]	1.0	[illegible]	0.4	1.2	0.2	0.2	[illegible]	0.3	[illegible]	[illegible]

8.4.4 Agricultural land use and incomes by sector

Changes in land use

Table 8-10 shows the percentage changes in land use compared with the Base Case under the three scenarios. In the arable sectors the major change due to the UR is an increase in the area under Oil Seeds throughout the EU. with smaller increases for Vegetables etc. (except in Germany), Sugar Cane/Beet and Other Agriculture; the areas under cereals fall throughout the EU. Agenda 2000 sharply reverses the falls in the cereals area throughout the EU (as would be expected with set-aside reducions), but whereas the areas under Oil Seeds and Sugar Cane/Beet rise in the UK compared with the UR outcome, they fall in Germany and the Rest of the EU. Abandoning the CAP leads to further substantial increases in the Wheat area in all countries/regions and a reduction in the area under Other Grains (major in the UK and Germany, but marginal in the Rest of the EU), and further expansion in the Oil Seeds and Sugar Cane/Beet areas in the UK and Germany, but a major reduction in areas under those crops in the Rest of the EU,

Table 8-10: Changes in Land Use **in the EU from Base Case (per cent)**

	UK			Germany			Rest of EU		
	UR	Agenda 2000	CAP	UR	Agenda 2000	CAP	UR	Agenda 2000	CAP
Wheal	-0,4	12.3	20,4	-0,3	10.4	32,3	-2.5	7,1	35,9
Oilier grains	-1.6	11.2	3.1	-1.7	8,7	-1,9	-0.9	8,5	7,6
Vegetables. fruit & nuts	1,2	4.1	14.6	-0.2	-0.1	1.5	LI	0.7	8,2
Oil Seeds	5,8	6,9	15.7	8,0	7,2	17.2	8.5	4.6	-23,7
Sugar Cane & Beet	1.2	3,4	15.0	0,4	0,2	6,7	0,6	0,4	-5,9
Other Agriculture	1,8	5,6	10.0	1.6	1.7	-3,2	0,4	0,0	1.4
Cattle. Sheep & Goats	-2,5	-10,4	-24,9	-2.5	-3,7	-25,6	-4,9	-3,5	-35.1
Other Livestock	0,0	2,7	2,0	0.1	0,0	3,6	0,0	0,0	2,6
Ran Milk	1.2	5,5	13.0	0.4	2,2	5,7	0,6	2,4	4,3
Set Aside	0,0	-80,0	-100,0	0,0	-63,0	-100.0	0,0	-55,0	-100.0

In the other agricultural sectors, the area under Cattle, Sheep and Goats falls throughout the EU with the UR compared to the Base Case, while that used for Raw Milk production increases. Compared with the UR outcome, Agenda 2000 results in reductions for Cattle etc. in the UK and Germany (much larger in the UK) but a small rise for the Rest of the EU; Raw Milk area rises throughout the EU. Finally, abandoning the CAP reduces the area for Cattle etc. very substantially throughout the EU, with some minor increases in Raw Milk areas.

Changes in agricultural income

Table 8-11 shows changes in agricultural factor income by sector relative to the Base Case **for** the three scenarios for the EU and for the three countries/regions. Many of the changes from meeting the Uruguay Round commitments are relatively minor, so attention will be focused on those exceeding $0.5bn for the whole EU. There are falls in income in the Wheat and Other Grains sectors for all countries, but the overall EU reductions of over $0.8bn and nearly $0.7bn respectively are largely accounted for by the Rest of the EU. These falls in arable income are more than offset for the EU as a whole by the increase for the Sugar Cane/Beet sector of over $2.2bn, although here Germany's increase exceeds that in the Rest of the EU.

Income for the Cattle, Sheep and Goats sector falls by nearly $1,4bn for the EU as a whole, with much of this occurring in the Rest of the EU. However EU-wide income from Raw Milk increases by over $31bn, of which the UK gets $4.38bn, Germany $7.7bn and the Rest of the EU $19.2bn. These increases in Raw Milk income are largely responsible for the overall increases in agricultural incomes in each country/region of the EU under the UR scenario.

Agenda 2000 reduces agricultural incomes relative to the UR outcomes in all countries/regions, and in the case of the UK to below the Base Case income. Although there are losses for **all** countries in most arable sectors, the major source of these changes is a fall in Raw Milk income relative to the UR outcome.

Abolition of the CAP reduces total agricultural incomes for the EU as a whole by nearly $79bn, with the falls being $11.7bn for the UK. $16.9bn for Germany and $50.3bn for the Rest of the EU. The Rest of the EU loses substantially in every sector (the range being from nearly $1bn in Vegetables, Fruit and Nuts to $24bn in Raw Milk). The major source of the fall in agricultural income for the UK is also in Raw Milk ($6.8bn), but there are also substantial reductions in Cattle etc. ($1.7bn), Wheat ($0.9bn). Other Grains and Sugar Cane/Beet (almost $0.6bn each). German income reductions are also dominated by those in Raw Milk ($8.8bn), and there are also substantial losses in Sugar Cane/Beet (almost $2.6bn), Wheat, Other Grains and Cattle etc. (around $1bn each).

Table 8-11: Changes in Agricultural Incomes Relative to the Base Case ($bn)

	UK			Germany			Rest of EU			All EU		
	UR	Agenda 2000	CAP	UR	Agenda 2000	CAP	UR	Agenda 2000	CAP	UR	Agenda 2000	CAP
Wheat	-0.129	-0278	-0.947	-0.132	-0.232	-0,940	-0.559	-0.854	-4.151	-0.82(1	-1.364	-6,038
Other grains	-0082	-0.165	-0.594	-0.149	-0.251	-1.099	-0.432	-0.725	-4553	-0.663	-1141	-6.246
Vegetables. fruit & nuts	-0.022	-0.029	-0.101	-0.049	-0.027	-0.435	0.016	0(147	-0.992	-0.055	-0009	-1.528
Oil seeds	-0.017	-0.06(1	-0,228	-0.005	-0.042	-0.351	0009	-0.222	-2.067	-0.013	-0.324	-2.646
Sugar Cane & Beet	0.088	0.'01	-0.583	1.39(1	1.808	-2.557	0.741	0.785	-3.096	2.219	2.694	-6.236
Cattle. Sheep & Goats	-0.239	-0.535	-1.729	-0.110	0(149	-1.010	-1.014	0.311	-5,750	-1.363	-0.175	-8.589
Oilier Livestock	-0.036	-0(145	-0.269	-0,069	-0.043	-0,727	-0.125	-0.065	-1.013	-0.230	-0.153	-2.009
Raw Milk	4.307	0.953	-6803	7.655	2.199	-8815	19.228	7.204	-24.018	31.190	10.356	-39.636
Other Agriculture	-0.001	0.008	-0.121	0.024	0.036	-0.332	-0.141	-0.139	-2323	-0.118	-0.095	-2.776
Set-aside payments	0	-0.226	-0.282	0	-0.426	-0,654	0	-1,293	-2.291	0	-1945	-3,227
TOTAL	3,869	-0,275	-11.657	8,555	3.072	-16.921	17.723	5.05	-50256	30.147	7,847	-78.834

8.5 CAP EXPENDITURES AND COUNTRY/REGION NET CAP BUDGETS

Table 8-12 gives estimates of the effects of the UR. Agenda 2000 and CAP abolition on the net CAP budget for the UK, Germany and the Rest of the EU. Tables 8-13a and 8-13b give a breakdown of changes in CAP E.xpenditure by country/region compared with the Base Case, in $bn and ECU bn respectively, while Table 8-14 gives a breakdown by sector. The UR commitments result in an increase of some 5.2 bn ECU for the EU as a whole compared with the Base Case, largely due (as Table 8-13b shows) to increases in purchases into stock to meet the UR export subsidy commitments (Table 8-15 shows EU stock purchases as a percentage of 1995 output), but also due to an increase in other FEOGA Guarantee e.xpenditure. Agenda 2000 more than reverses the increase in CAP expenditure due to the UR. CAP abolition, of course. results in a very substantial saving, estimated at over 48 bn ECU.

Table 8–12: Net CAP Budget (Sbn, real 2005 dollars)

	1995 Base Data	Base Case	Uruguay Round	Agenda 2000
UK				
CAP E.xpenditure	8,490	10.081	10,535	8.623
Tariff + Levies Contribution	6.311	9,606	7,943	7,694
Resource Contribution	3,000	1.591	3,374	2.670
Net Budgetary Gain	-0.821	-1.116	-0,782	-1.742
Germany				
CAP Expenditure	12,757	12.460	14.218	12.715
Tariff + Levies Contribution	7,717	12.199	8,652	8.606
Resource Contribution	9,280	4,922	10,436	8.259
Net Budgetary Gain	-4,240	-4.661	-4,869	-4.150
Rest of EU				
CAP Expenditure	39,956	41,436	46.131	41,745
Tariff + Levies Contribution	16.243	25,767	19,503	19.253
Resource Contribution	21,436	11.369	24,107	19.079
Net Budgetary Gain	2,277	4,300	2.521	3,414
All EU				
CAP Expenditure	61,203	63,977	70,884	63.083
Tariff + Levies Contribution	30,272	47,571	36,098	35.553
Total Resource Contribution	30,932	16,406	34,786	27.531
Net Budgetary Gain	0,000	0,000	0,000	0.000

In the results presented in Table 8–12, the total over the EU of resource contributions to the CAP budget is calculated as total CAP expenditure for the whole EU less the total of tariff plus levies contributions. Each region has a constant share of the total resource contribution, these shares being 9.7% for the UK, 30.0% for Germany, and 60.3% for the Rest of the EU. The net budgetary gain for each region is calculated as regional expenditure less the regional tariff + levy and resource contributions.

For the UK the national CAP expenditure is some $1.5bn higher in the Base Case than in 1995. The tariff + levies contribution is higher in the Base Case by $3.3bn, but the resource contribution is lower by $1.4bn. so that overall the UK's net budgetary loss in the Base Case is just under $0.3bn higher than in 1995. National CAP expenditure would rise by $0.5bn compared with the Base Case under the UR scenario, largely due to the costs *of* meeting UR commitments. The tariff + levies contribution would fall by just over $1.6bn, but the resource contribution would rise by nearly $1.7bn. The net budgetary loss under the UR scenario would thus be slightly lower than in the Base Case at just under $0.8bn. Finally. comparing the UR scenario with Agenda 2000. the UK would see a$I.9bn reduction in its CAP expenditure. with a minor fall in its tariff + levies contribution and just over a $9.5bn cut in its resource contribution, resulting in a net budgetary loss for the UK of $1.742bn.

For Germany there are relatively small changes in its CAP expenditure and net budgetary loss between the Base Case and 1995. but substantial (and almost off-setting) changes in the pattern of its contributions. The UR scenario results in a $1.8bn increase in its CAP expenditure compared with the Base Case, a reduction in its tariff + levies contributions of S3.5bn. but a rise in its resource contribution of some $5.5bn, so that its net budgetary loss increases marginally, by about $0.2bn. The Agenda 2000 results show a $1.5bn fall in Germany's CAP expenditure compared with the UR expenditure. little change in its tariff + levies contribution, but a reduction of over $2bn in its resource contribution. so that its net budgetary loss is reduced by just over $0.7bn.

The Rest of the EU has higher CAP expenditure in the Base Case than in 1995 but, like the UK and Germany, almost offsetting switches between its tariff + levies and resource contributions, so that its net budgetary gain increases by approximately the same amount as its CAP expenditure. The UR scenario shows a $4.7bn increase in CAP expenditure, a fall in tariff + levies contribution of over $6bn but a rise in the resource contribution of just under $13bn.so that the Rest of the EU finds its net budgetary gain reduced by some $1.8bn compared with the Base Case. Agenda 2000 reduces the CAP expenditure by over $4.4bn compared with the UR outcome, leaves the Rest of the EU tariff + levies contribution almost unchanged, but does result in a $5bn reduction in resource contribution, yielding a net budgetary gain of just under $0,9bn compared with the UR.

As Tables 8-13a and 8-13b show, the increases in CAP expenditure due to meeting the UR commitments are largely due to increases in intervention buying to constrain subsidised exports and in "Other FEOGA Guarantees"; these are offset to a limited extent by reductions in expenditure on those export subsidies and in compensation and headage payments and intervention to support market prices.

Table 8-13a: Changes in CAP E.xpenditure by Country from Base Case (Sbn)

	UK			Cermany			Rest of EU			All EU		
	UR	Agenda 2000	CAP	UR	Agenda 200(1	CAP	UR	Agenda 2000	CAP	UR	Agenda 2000	CAP
E,\p()rt Subsidies	-0.112	-0.135	-1.108	0.055	0.037	-2.494	-0.398	-0,409	-10.051	-0.454	-0,507	-13.652
Comp+Headage Payments	-0.310	-(1,486	-2.428	-0.316	-0,350	-2,633	-1.126	-0,653	-11.374	-1.752	-1.489	-16.435
Set Aside Payments	0,000	-0,226	-02X2	0.000	-0,426	-0,654	0,000	-1,293	-2.291	0,000	-1.945	-3.227
Intervention (support)[a]	-0.153	-0.X78	-0.X7X	0,000	0,000	0,000	0,000	0,000	0,000	-0.153	-0,878	-0,878
Intervention (export)[b]	0.468	0,303	0.000	1.175	0,753	0,000	3,997	1.X29	0.00(1	5.640	2,885	0,000
Other FEOGA Guarantee[c]	0.4X7	-0,023	-4.601	(1,727	0.211	-5.709	1.901	0.716	-15.161	3.116	0,904	-25.471
FEOGA Guidance	0,082	-0,004	-0,776	0.123	0,036	-0,963	0.321	0.121	-2,558	0,526	0.153	-4,297
TOTAL	0,463	-1.448	-10.072	1.764	0.261	-12.454	4.695	0.310	-41.435	6.923	-0,878	-63,961

a; support buying; b: purchases into stocks to meet UR commitments on subsidised e.vports; c: miscellaneous

Table 8–13b: Changes in CAP Expenditure by Country from Base Case **(Ecu bn)***

	UK			Germany			Rest of EU			All EU		
	UR	Agenda 2000	CAP	UR	Agenda 2000	CAP	UR	Agenda 2000	CAP	UR	Agenda 2000	CAP
Export Subsidies	-0,084	-0,101	-0.832	0.041	0.028	-1.874	-0,299	-0,307	-7.551	-0.341	-0.381	-10,256
Comp+Headage Payments	-0,233	-0,365	-1,824	-0,237	-0.263	-1,978	-0,846	-0.491	-8,545	-1.316	-1.119	-12,347
Set Aside Payments	0,000	-0.170	-0.212	0.000	-0,320	-0,491	0,000	-0.971	-1.721	0.000	-1.461	-2,424
Intervention (support)[a]	-0.115	-0,660	-0,660	0,000	0,000	0,000	0,000	0,000	0.000	-0.115	-0.66(1	-0,660
Intervention (export)[b]	0,352	0,228	0,000	0.883	0,566	0,000	3,003	1,374	0.000	4.237	2.167	0,000
Other FEOGA Guarantee[c]	0,366	-0.017	-3.457	0,546	0.159	-4289	1,428	0,538	-11.390	2.341	(1,679	-19,135
FEOGA Guidance	0,062	-0,003	-0,583	0,092	0,027	-0,723	0.241	0,091	-L922	0.395	0.115	-3,228
TOTAL	0,348	-!,08X	-7,567	1.325	0,196	-9,356	3,527	(1.233	-31.128	5,201	-0.660	-48.051

* Derived from Table 8–13 at an exchange rate of 1 Ecu = $ 1.3311.
a: support buying; b: purchases into stocks to meet UR commitments on subsidised e.xports; c: miscellaneous

Agenda 2000 marginally reduces CAP expenditure compared to the Base Case for the EU **as a** whole, but this is a case of a reduction in UK expenditure outweighing increases elsewhere. Abolition of the CAP necessarily yields large reductions everywhere.

Tabic 8-14:Changes in Total CAP Expenditure by Commodity from Base Case (Sbn)

	Wheat			Other Grains			Oil Seeds			Set Aside		
	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP
Export Subsidies	-0.322	-0,325	-0,365	-0,381	-0.391	-0,618	0,000	0,000	0.000	0.000	0,000	0,000
FEOGA Guidance	-0.002	-0,002	-0,049	-0.001	-0,002	-0,044	0,016	0.016	-0.318	0.000	0,000	0,000
FEOGA Guarantee[a]	-0.011	-0.012	-0.291	-0,009	-0,009	-0,260	0,094	0,096	-1.886	0.000	0,000	0,000
Compensation + Headage	-0,667	-1,225	-6,340	-0,577	-1,055	-5,762	-0.116	-0,522	-2.237	0,000	0,000	0,000
Set Aside Payments	0,000	0,000	0000	0,000	0,000	0,000	0,000	0,000	0.00(1	0,000	-1.945	-3.227
Intervention (support)[b]	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0.000	0,000
Intervention (export)[c]	0,147	0.143	0,000	(1.444	0,439	0,000	0,000	0,000	0.000	0,000	0.000	0,000
TOTAL	-0,855	-1.420	-7.045	-0.523	-1.018	-6,684	-0,005	-0.410	-4.442	0.000	-1.945	-3,227

	Vegetables, Fruit & Nuts			Sugar Cane & Beet			Cattle, Sheep & Coals			Other Agriculture		
	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP
Export Subsidies	0,000	0,000	0,000	0.043	(1,043	-0,096	-0.781	-0,809	-1,313	0(100	0.000	0.000
FEOGA Guidance	0.000	0,000	-0.104	0,000	0,000	0,000	-0.015	-0-048	-0.881	0,000	0.000	-0.210
FEOGA Guarantee[a]	-0,003	-0.001	-0,614	0,000	0,000	0,000	-0,089	-0,284	-5,222	-0.001	0,000	-1.247
Compensation + Headage	0,000	0,000	0,000	0,000	0,000	0,000	-0,393	1.313	-2,095	0,000	0,000	0,000
Set Aside Payments	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Intervention (support)[b]	0,000	0,000	0,000	0,000	0,000	0,000	-0.153	-0,878	-0,878	0,000	0,000	0,000
Intervention (export)[c]	0,000	0,000	0,000	0.158	0.173	0,000	0,303	0.296	0.000	0,000	0,000	0,000
TOTAL	-0,003	-0,002	-0.717	0,200	0.216	-0,096	-1.127	-0,409	-10.388	-0,001	0,000	-1,458

	Other Agric Products			Raw Milk			Cattle Meat			Other Meat		
	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP
E.xport Subsidies	-0,461	-0.469	-0.503	0,000	0.000	0,000	-0,459	-0,459	-1.757	-0.836	-0,840	-0,898
FEOGA Guidance	0.001	-0.002	-1.103	0.471	0.163	-1,036	0,00(1	0,000	-0.085	0.002	0,001	-0,129
FEOGA Guarantee[a]	0,007	-0,012	-6.539	2,792	0,965	-6,140	0,002	0,000	-0,502	0,009	0,006	-0,764
Compen.sation + Headage	0,000	0,000	0.000	0,000	0,000	0,000	0,000	0,000	0.000	0,000	0,000	0,000
Set Aside Payments	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Intervention (support)[b]	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Intervention (export)[c]	0.119	0.119	0,000	0,000	0,000	0,000	0,770	0,712	0.000	0,298	0.247	0,000
TOTAL	-0,333	-0,365	-8,145	3.263	1,127	-7,176	0.314	0,252	-2,344	-0528	-0,585	-1.791

	Vegetable Oils			Milk & Milk Products			Sugar			Other Food		
	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP	UR	Ag	CAP
Export Subsidies	0,000	0,000	0,000	2,443	2.443	-6,420	0,300	0,300	-1,682	0,000	0,000	0,000
FEOGA Guidance	0.001	0,001	-0,035	0,050	0.022	-0,246	0,003	0.004	-0.057	0,000	0,000	0,000
FEOGA Guarantee[a]	0,006	0,006	-0,209	0,297	0.129	-1.459	0,021	0,022	-0.338	0,000	0,000	0,000
Compensation + Headage	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0.(100	0,000	0,000
Set Aside Payments	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0.000	0,000	0,000
Intervention (support)[b]	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,00(1	0,000	0,000	0,000
Intervention (export)[c]	0,000	0,000	0,000	2.849	0.175	0,000	0,552	0,579	0,000	0,000	0,000	0,000
TOTAL	0.007	0,007	-0.244	5,640	2,769	-8,125	0,876	0,906	-2.077	0.000	0,000	0,000

a: miscellaneous; b: support buying; c: export subsidies

Table 8-15: EU Stock Purchases as a percentage of 1995 output

	Base Case	**Uruguay Round**	Agenda 2000
Wheat		0,87	0,86
Other Grains		2,48	2,48
Sugar cane/beet		0.96	1.03
Cattle, Sheep & Goats[a]	2,45	2.85	0,82
Other Livestock		0.16	0.16
Cattle Meat		0.84	0,70
Other Meat		0,24	0,20
Vegetable Oils		0.04	0,03
Milk & Milk Products		1.42	0,10
Sugar		1,04	1.09
Other Food		0,08	0,06

a: Cattle. Sheep & Goats includes purchases to support the intervention price in the Base Case and Uruguay Round scenarios. All other stock purchases are those necessary to meet the Uruguay Round commitments.

8.6 THE DECOMPOSITION OF WELFARE GAINS FOR THE EU

8.6.1 Changes in EV

Table 8-16 gives a sectoral decomposition of the EV changes for the EU and its member regions.[2] This (discussion will, because it is the (dominant reform as far as the UK is concerned, concentrate largely on the effects of abolishing the CAP. The most obvious features are that all the identified EU members experience a substantial net loss in the Agriculture sectors that dominates a substantial gain in the Food sectors. Nevertheless, all EU members enjoy a strong overall gain from CAP removal. For the UK the major source of gain is in the Services sector while for Germany it is in Manufactures, and for the Rest of the EU there are gains in both (although the Services sector yields the greater gain). Note that the gains and losses in the individual groups of sectors most affected are substantial relative to the overall gain: inter-sectoral transfers exceed net gains by a large multiple.

2 The decomposition is a first-order approximation, hence the 'Other Terms' row in the table. A Full decomposition would require the calculation of the effects of interactions between all possible pairs of sectors, all possible triples, all possible quadruples........

Table 8-16: EV Decomposition for the EU (all $bn changes from Base Case)

	UK			Germany			Rest of EU			All EU		
	UR	Agenda 2000	CAP	UR	Agenda 2000	CAP	UR	Agenda 2000	CAP	UR	Agenda 2000	CAP
Agriculture	[illegible]	[illegible]	-5.771	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-25,544	[illegible]	[illegible]	-40,387
Food	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-6.441	[illegible]	-29,027	[illegible]	[illegible]
Manufactures	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-6,720	[illegible]	[illegible]
Services	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0,277	[illegible]
Other Terms	[illegible]	0,055	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.835	-0.160	[illegible]	1,384	-0.809
Total EV	[illegible]	0,105	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6.417	-6.441	[illegible]	9.251
Terms of trade	[illegible]	-0,557	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-0.496	[illegible]	[illegible]	-0.988
Agriculture	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.129	-0.027	0.145	0.145	0.404
Food	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.465	[illegible]	0.581	0.139	[illegible]
Manufactures	[illegible]	-0.304	[illegible]	-0.578	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-0.404	[illegible]	[illegible]
Services	[illegible]	-0,06	[illegible]	[illegible]	-0.097	[illegible]	[illegible]	-0.283	-0.875	-0.516	-0.440	[illegible]

8.6.2 Welfare gains and transfers in agriculture and food

Table 8-17 and Table 8-18 provide details, for the EU, of the decomposition into producer effect, consumer effect and tax revenue changes of the losses and gains in EV in the agriculture and food sectors respectively in the EU. They should be read together with Table 8-16 as they illustrate two of the points made earlier: that the general equilibrium effects of reform in one sector may dominate the gains/losses in that sector, and that transfers (redistributions of welfare) almost always exceed efficiency gains by a substantial multiple.

As an initial example of the first point, note from Table 8-16 that, for the UK. the individual EV changes due to the abolition of the CAP in the agriculture and food sectors, though individually substantial (a $5.771bn loss and a $5.443bn gain respectively) they virtually offset one another. It may also be seen from Table 8–16 that the net gains elsewhere in the UK economy (notably in Services) dominate the small net loss in the agricultural and food sectors. That is. the main gains do not come from gains in the sectors directly affect by the abolition of the CAP. but from changes in other sectors, and there are substantial transfers between the directly-affected sectors.

As a further example of the relative dominance of transfers, consider the aggregated changes from Table 8-17 and Table 8-18 for the agriculture and food sectors in producer and consumer effects and tax revenue (the conventional partial equilibrium components of welfare changes). Abolition of the CAP would reduce producer prices, leading to a producer effect of $-12.076bn, and would benefit consumers by $7.278bn and taxpayers by $4.470bn. All these transfers dominate the net loss in agriculture and food.

8.6.3 Agenda 2000 in 2005 compared with CAP abolition in 2005

The first of our scenarios assumes that the EU will meet its Uruguay Round commitments. Given that, it is interesting to ask how far that Agenda 2000 reforms of the CAP go towards realising some of the welfare gains to the EU countries that would come from the complete abolifion of the CAP. In terms of its EV (consumer) effects, Agenda 2000 does not perform very well. Using the data in Table 8-16, we observe that while Agenda 2000 does give EV gains relafive to the UR scenario ($0.58bn for the UK, $0.28bn for Germany. $l.02bn for the Rest of the EU), they are minimal compared to the gains from CAP abolition ($2.38bn for the UK, $2.63bn for Germany. $10.6bn for the Rest of the EU).

Table 8-17: Sources of EV for agriculture in the EU

	UK			Germany			Rest of EU			All EU		
	UR	Agenda 2000	CAP	UR	Agenda 2000	CAP	UR	Agenda 2000	CAP	UR	Agenda 2000	CAP
Producer effect	3,869	-0,275	-11.657	8,555	3,072	-16,921	17.723	5.05	-50,256	30,147	7,847	-78,834
Consumer effect	-0,024	0,062	0,542	-0.106	-0,093	-0.137	-0,088	-0,055	0,999	-0.218	-0086	1404
Net tax revenue	0,127	1,495	5,344	-0,365	0.561	7,986	-0.13	1,862	23,713	-0,368	3,918	37043
of which:												
Output taxes and subsidies	-0,328	0,080	2,945	-0,593	-0.126	5,023	-1,639	-0,580	12.911	-2,560	-0,627	20,879
Export taxes and subsidies	0,197	0,207	0,336	0,338	0,342	0,613	1.146	1.173	1,545	1.682	1.722	2,494
Compensation payments	0,250	0,392	1.969	0,248	0,275	2.091	0.917	0,533	9,357	1.415	1.200	13,418
import tariffs	0,019	0,016	-0,896	-0,025	-0.024	-0,404	-0.011	-0,046	-2,402	-0.017	-0,054	-3,701
Stocks	-0.010	0.574	0,706	-0,327	-0,329	0,000	-0,482	-0.481	0,000	-0.819	-0,235	0,706
Other taxes	0.000	0,000	0,000	-0,007	-0,002	0,009	-0,061	-0,030	0.011	-0,068	-0,032	0,020
Set-aside compensation	0	0,226	0,282	0	0,426	0,654	0	1,293	2.291	0	1,945	3.227
Total EV	3.972	1,282	-5,771	8,083	3,540	-9,072	17,505	6,857	-25,544	29,560	11.679	-40,387
Terms of trade	0,002	-0.017	0,099	0,041	0.033	0,331	0,102	0.129	-0,027	0.145	0.145	0,404
of which:												
Export prices	0,059	0,034	0,271	0.115	0,099	0,632	0,480	0,393	1.076	0,654	0.527	1.979
Import prices	-0,057	-0.051	-0.171	-0,074	-0,066	-0.301	-0,378	-0.264	-1.102	-0.509	-0382	-1.575

Table 8–18: Sources of EV for food in the EU

	UK			Germany			Rest of EU			All EU		
	UR	Agenda 2000	CAP	UR	Agenda 2000	CAP	UR	Agenda 2000	CAP	UR	Agenda 2000	CAP
Producer effect	0,058	0,407	-0.419	-0462	-0.106	-1.803	0,107	0,919	-5,284	-0,297	1,220	-7,505
Consumer effect	-2,360	-0,574	6,736	-7,327	-3.574	9,739	-13.800	-5.159	23,944	-23,487	-9,306	40.419
Net tax revenue	-0,260	-0,270	-0,874	-1.143	-0,830	-0,673	-3,840	-2,202	2.014	-5,244	-3,302	0467
of which:												
Output taxes and subsidies	-0,114	-0,042	1.393	0016	0,029	-0,272	-0,035	0,029	0,926	-0.133	0.017	2,046
Export taxes and subsidies	-0,098	-0,088	0,570	-0,381	-0.370	1.362	-0.829	-0,647	6,906	-1.108	-1,106	8,838
Import tariffs	0,195	-0,027	-2,837	-0,176	-0,222	-1.768	-0.341	-0,543	-5.819	-0,322	-0,792	-10.424
Stocks	0,000	0,000	0,000	-0,003	-0,003	0,005	-0,058	-0.031	0,001	-0,061	-0,034	0,006
Other taxes	-0,244	-0.1 12	0,000	-0,599	-0,265	0,000	-2,777	-1.011	0,000	-3.619	-1.387	0,000
Total EV	-2.562	-0,437	5,443	-8,932	-4.510	7,263	-17.533	-6.441	20,674	-29,027	-11.388	33,380
Terms of trade	-0.141	-0,176	0097	0,022	-0,150	0,847	0.700	0,465	3,939	0,581	0.139	4,882
of which:												
Export prices	0.371	0.109	-0,036	1,112	0,392	0,279	4398	2.063	1,243	5,881	2,565	1,486
Import prices	-0.512	-0,285	0.133	-1,090	-0,543	0,568	-3,698	-1.598	2,696	-5,300	-2,426	3,397

Table 8–19: Agriculture and Food Consumer Effects Relative to Base Case ($bn)

	UK			Germany			All EU			Rest of EU		
	UR	Agenda 2000	CAP	UR	Agenda 2000	CAP	UR	Agenda 2000	CAP	UR	Agenda 2000	CAP
Wheat	-0,001	0.000	0,003	000(T	0001	0.1)05	-0.001	0.01	0.027	-0.002	0014	0.035
Other grains	0,000	0,002	0.018	0.000	0 004	0 024	0.000	0.002	0.012	0.000	0.008	0 1)54
Vegetables. fruit & nuts	0.006	0.042	0.222	0.020	0.014	0.124	0082	0054	0823	0.108	I)110	1T69
Oil -seeds	-0.004	-0.004	-0.025	-0.009	-0.009	-0.064	-0.001	-0.001	-0.003	-0.014	-0.014	-0.092
Sugar Cane & Beet	-0,009	-0.009	0.315	-0,034	-0.043	0.071	-0.1)05	-0.006	0.029	-0 048	-0.058	0.-15
Callle, Sheep & Goats	0.001	00T9	0.062	-0.001	0(T00	-0.003	-0.015	-0.003	0.110	-0.015	0016	0 169
Other Livestock	-0,012	0,1)05	-0.11	-0.062	-0.041	-0.435	-0.158	-0.112	-0 539	-0,232	-0.148	-1 084
Raw Milk	0	0	0	0	0	0	0	0	0	0	0	0
Other Agriculture	-0,005	0,007	0.056	-1)020	-0.1)21	0.139	0.009	0.000	0.541	-0.016	-0.014	0.736
Callle Meat	-0,032	0,021	1.820	-0.055	-0012	1.825	-0.511	-0.052	5,347	-0.598	-0.043	8 992
Other Meat	-0,083	-0,003	-0,343	-0.355	-0,277	-0,202	-0,425	-0.242	-1,098	-0.863	-0,522	-1,643
Vegetable Oils	-0,004	-0,002	-0.029	-1)277	-0.157	0.233	-0.059	-0.041	-0.261	-0.340	-0.200	-0,057
Milk & Milk Prods	-1,804	-0.440	3 198	-4571	-1.420	4,992	-11.701	-4.210	13.887	-18.076	-6070	22.077
Sugar	-0.023	-0.024	0.301	-0898	-0,988	1.644	-0.138	-0,145	0,784	-1.059	-1,157	2,729
Oilier Lood	-0,414	-0.126	1.788	-1.170	-0,720	1.246	-0.966	-0.469	5,284	-2 550	-1.315	8318
TOTAL	-2.383	-0.511	7 278	-7.433	-3,667	9.60T	-13.889	-5,214	24 943	-23,705	-9.39[illegible]	41.82[illegible]

8.7 CONCLUSIONS

Table 8–1 shows a net loss relative to the Base Case for the EU (-0.07 per cent of EU GDP) **and** for all its identified members from the Uruguay Round agreement in terms of the equivalent variation measure of welfare for 2005; the UK loss is the smallest of the three (-0.04 per cent of GDP). It has been argued that one of the reasons for this is that the EU did not liberalise significantly, even in its agricultural policy, where relatively little reductions in its subsidised exports were in fact required. Indeed, all EU countries (households) gained in terms of the agricultural sectors, although these gains were largely offset by losses through changes in the food, manufactures and services sectors. There were substantial distributional changes (dominating the EV gains), both within agriculture itself, and between agricultural producers (the gainers) and food producers, consumers and taxpayers (the losers).

The Agenda 2000 reforms would, in 2005, change the UK's loss from the Uruguay Round into a small gain relative to the Base Case (0.01 per cent of GDP).. and would reduce the losses for Germany and the Rest of the EU. These changes again involve substantial redistributional effects. The gains are small compared with those that would come from the abolition of the CAP (0.10 per cent of GDP for the EU as a whole relative to the Base Case. 0.16 per cent for the UK, 0.04 per cent for Germany and 0.13 per cent for the Rest of the EU).

CHAPTER 9

CONCLUSIONS

This thesis has considered the evaluation of agricultural policy using computable general equilibrium modelling. The main focus of this study has been two applications, both of which are concerned with agricultural policy in the European Union. Chapter 6 presented the results from a model of the Uruguay Round that contained certain original features, and chapter 8 presented results from an updated model using a new database, and was concerned with the modelling of the Uruguay Round, Agenda 2000 agricultural reforms, and the total costs of the Common Agricultural Policy. The consideration of the Uruguay Round reforms included the modelling of non-agricultural policy changes, reinforcing the need for a general equilibrium approach to modelling.

There is a "standard" means of modelling trade reform in CGE models, characterised by static modelling, perfect competition with constant returns to scale, perfectly mobile factors within regions, and the use of *ad valorem* taxes and subsidies. The last decade has seen several major improvements in terms of the modelling of imperfect competition and the incorporation of projections and steady-state dynamics into CGE models, but all these improvements have focused on trade in manufactured goods with little consideration of the structure of the agricultural economy.

This thesis has presented extensions to this framework that attempt to bring a more realistic characterisation of the agricultural sectors. The incorporation of factor immobility in agriculture is necessary unless agriculture is to be treated as simply another manufacturing sector, and setting a proportion of agricultural factors to be sub-sector specific both improves the modelling of supply response in agriculture and allows the income of farmer households to be measured. This treatment has advantages over more traditional factor immobility models where one factor is sector-specific, because in those models the factor intensity ratios determine how far the immobility affects different sectors. The use of *ad valorem* tax and subsidy rates in agriculture has been adapted to enable the modelling of Uruguay Round constraints, and chapter 5 introduced the modelling of set-aside. The model of chapters 7 and 8 defined several CAP instruments explicitly - compensation and headage payments, output quotas, set-aside and set-aside compensation, intervention prices and support buying - and introduced a new means of modelling the Uruguay Round export subsidy commitments for the EU.

Chapter 1 described the Uruguay Round agreement, with particular attention being paid to the Agricultural Agreement, of which there are three main areas of reform: market access, export subsidies, and domestic support commitments. The market access commitments involve the conversion of non-tariff barriers to tariffs, and the reduction of these and existing tariffs. 'Dirty tariffication' and various exemptions to the market access commitments such as the continuation of Japanese rice import quotas, are likely to water down the effects of the tariff reductions, but the inclusion of agriculture into GATT/WTO disciplines is certainly a large step forward and lays the foundation for future tariff reforms. The reform of export subsidy and domestic support commitments will also not have as large an effect as was expected at the beginning of the Uruguay Round negotiations, mainly because the base periods for reductions were ones where agricultural support was at historically high levels.

Chapter 2 examined the construction of computable general equilibrium models, from basic functional forms to issues of product differentiation and model closure. This discussion laid the foundation for chapter 3, which considered the Global Trade Analysis Project (GTAP) model, and presented the results from se\eral papers that use this model for the analysis of the Uruguay Round, as well as other Uruguay Round CGE models. The results from these models vary widely, depending on the commodity and regional classification of the models, the market structures, the approaches to dynamics and projections, and the representation of the reform package.

The GTAP version 2 database was examined in chapter 4. The structure of trade patterns and of agricultural protection in each of the 24 regions of the database was discussed as the basis for an aggregation of the GTAP database that has the specific emphasis of modelling agricultural policy. Chapter 5 discussed the standard GTAP model, and made modifications and extensions to this model. The modelling of specific-factors and endogenous subsidy rates was developed here, as was a means of decomposing welfare changes in the GTAP model.

Chapter 6 presents the results from modelling the Uruguay Round with the aggregation and model developed in chapters 4 and 5. The main results for these simulations show that the global welfare gain (0.39%) and regional gains to the EU (0.42%). the USA (0.41%) and Japan (0.84%) are comparable to the other studies discussed in chapter 3. Agriculture, textiles and clothing and market access for industrial goods are found to each provide around one third of the global gains, but with a great degree of inter-regional differences. Agricultural import tariff reforms have far greater importance for the world as a whole than subsidy reforms. but in the EU export subsidy reforms are the most important aspect of the Uruguay Round.

On the level of aggregate welfare. the modelling extensions developed here lead to slightly lower welfare impact from reforms. but on a sectoral level the results from using a "standard" model and the `main model' of chapter 6 are very different for agricultural sectors. and for farm income. The modelling of imperfect compefition. meanwhile. changes the farm income results very little.

The recently released GTAP version 4 database provides greater commodity detail in agricultural sectors. which allows modelling of CAP policies on a detailed basis, and chapter 7 developed the framework for this, in the context of modelling the Agenda 2000 reforms. The model developed in chapter 5 was augmented with producfion quotas for milk and sugar, explicit compensation and headage payment modelling, intervention price and support buying. and a model of the EU export subsidy commitments where the EU maintains the domesfic price of exports via a variable export levy and ensures that Uruguay Round commitments are met through support buying.

Chapter 8 provided results for simulations using this updated database and CAP policy modelling in a projected model. The main results are that the Uruguay Round leads to welfare losses in the EU. which are partially reduced through Agenda 2000. The Agenda 2000 reforms are very small considered against the complete abolition of the CAP. The main reason why the Uruguay Round results in this chapter differ from those in chapter 6 is that the characterisation of the Uruguay Round Agricultural Agreement in chapter 6 is 'optimistic', whereas the tariff liberalisation and export subsidy commitments detailed in chapter 7 result in far less reform of EU agriculture. The MFA reforms, which could lead to overall welfare gains, were also not modelled in chapter 8, and the industrial sector was not disaggregated; which has probably lead to underestimation of the welfare gains from the Uruguay Round. In all three counterfactual scenarios modelled in this chapter, the redistributional impacts of reforms are far greater than the overall welfare results.

Opportunities for future research exist in several areas of the work conducted here. Modelling of the CAP could be improved by including milk subsidies and modelling compensation payments as specific subsidies to land (in chapters 7 and 8 they are *ad valorem* subsidies to land). Explicit modelling of agricultural policies outside the EU presents many opportunities for more detail to be included into the modelling framework, particularly in the USA and Japan. The Uruguay Round Agricultural Agreement contains several areas that have not been modelled here, such as minimum import access commitments, and the remaining quotas on Japanese rice imports. The inodelling of imperfect factor mobility in agriculture could also be expanded to more than create a 50-50 split between perfectly mobile and immobile factors, with the possibility of using data on the proportion of farm owners in the agricultural workforce to determine the rafio of specific agricultural factors. Then there are possibilifies of modelling other categories of agricultural labour with varying degrees of mobility.

On a wider scale, there are 'new' areas of CGE modelling such as multi-period dynamics and the use of trade restrictiveness indices that are applicable to all forms of CGE modelling. Multi-period dynamics have only been used in small dimension CGE models because of the rapid increase in model size that they dictate, but with techniques similar to those used in chapter 5 to compress the model, it may be possible to generate multi-period dynamics for large scale CGE models. The trade restrictiveness index is a means of incorporating the effects of tariff or tax vanafions within an aggregated commodity grouping, and may be crucial in CGE models where the level of aggregation means that tariff peaks are hidden in large commodity groups with low(er) average tariffs.

There exist possibilities to augment the GTAP database with data on agricultural goods at a far more detailed level. It is possible to formulate a large global model where the commodity classification is expanded for a subset of the regions in the model, enabling for example grains production in, and trade between, the EU, USA and Canada to be disaggregated into a dozen categories, while retaining a more aggregate classification in other regions. This would also be of importance to the livestock and milk sectors in the EU and other regions, and to non-food crops (coffee, cocoa, etc.) in LDCs. Only when this level of detail is reached will CGE models be able to generate serious commodity forecasts.

While the modelling of imperfectly competitive markets has tended to concentrate on manufacturing and services sectors, there are possibilities for future research to develop models that incorporate forms of imperfect competition that are more relevant to agriculture. Monopsonistic competition (concentration of *buyers)* is a feature of food processing sectors, where food retailers have market power over the goods that they purchase from the agriculture sector. The implications of this and monopolisfic compefition among multi-product food retailers could also be investigated in a CGE framework, as could market concentration in the trading sector - there is a high concentration of international companies trading in cereals, for example.

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