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General Equilibrium Analysis of the CAP using the GTAP Model

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Abstract

Although partial equilibrium analysis dominates agricultural policy modelling, there are instances where a broader economy-wide approach is more appropriate. Accordingly, this paper uses a global general equilibrium framework, provided by the GTAP model, to assess the domestic and international implications of the Common Agricultural Policy. In character with this type of model, the shuffling of global resources induced by the CAP is shown to lead to significant structural changes in the economies of all regions, particularly with respect to trade flows. Net welfare impacts, arising from efficiency and terms of trade effects, are smaller in comparison, with the European Union worse off by 0.8 per cent and the world by 0.4 per cent. It is argued that applied general equilibrium modelling is deserving of greater attention.

1. Introduction

Applied general equilibrium (AGE) modelling is a technique which the agricultural economics profession, particularly within the UK, chooses largely to ignore, preferring instead to concentrate on partial equilibrium analysis. This predilection has its advantages, but there are instances where a broader economy-wide approach is more appropriate. Moreover, recent developments lend support to the idea that AGE modelling could soon become a routine exercise. This paper addresses the use of AGE modelling in agricultural policy analysis and reports on an application which highlights the domestic and international consequences of the Common Agricultural Policy (CAP) of the European Union (EU).

Over the past fifteen years, the costs of the CAP have been examined extensively through use of partial equilibrium analysis. For example, Harvey and Thomson (1985) reported an efficiency loss of just under 0.5 per cent (US $ 11,000 million) of EU Gross Domestic Product (GDP). This estimate was based on a model which provided detailed coverage of agricultural markets in individual member states within the EU, but which neglected effects in non-agricultural markets and understated international repercussions. It is widely recognised that the CAP, as with agricultural protection in general, effectively taxes non-agricultural sectors of the economy and that the distortions created extend beyond national and supra-national boundaries.

Indeed, the international trade and welfare implications of the CAP have also been analysed extensively, but again largely within a partial equilibrium setting. For example, Tyers and Anderson (1992) estimate that EU agricultural policies result in an annual global net economic loss of US $ 17,000 million.

The economy-wide effects of the CAP have been addressed far less often. Dicke *et al* (1989) and Stoeckel and Breckling (1989), using computable general equilibrium (CGE) models, showed the CAP to impose significant costs in terms of a loss of competitiveness in manufacturing, lower manufacturing output and exports, lower economic growth and higher unemployment. Earlier, Stoeckel (1985), assuming complete wage rigidity, had claimed that the CAP was responsible for a loss of one million jobs in the EU manufacturing sector. In the aftermath of these CGE analyses one might have expected to see, particularly within Europe, a proliferation of this type of modelling of the CAP, focusing on both domestic and international issues. This has not occurred, although growing interest in the development and application of CGE models, particularly within the context of multilateral trade negotiations, has occasionally resulted in CAP-related issues being addressed (see, for example, McDonald, 1990 and Hertel *et al*, 1992).

The reasons why the agricultural economics profession has favoured partial equilibrium over general equilibrium are summarised in Section 2. The remainder of the paper then reports on an application of a multi-region general equilibrium trade model, in which the economy-wide implications of the CAP, both within the EU and in other parts of the world, are assessed. The salient features of this Global Trade Analysis Project (GTAP) model are described in Section 3 and simulation results are presented in Section 4.

2. General Equilibrium vs. Partial Equilibrium

General equilibrium (GE) is concerned with the interdependence between markets in an economic system. In essence, it can be represented in terms of excess demand:

$$D_i - S_i = E_i = E_i\,(p_1, p_2, ..., p_n), \qquad (1)$$

where D_i, S_i, E_i and p_i = demand, supply, excess demand and price in market i, (i = 1, 2, ..., n). All n markets are treated as endogenous and an equilibrium solution is achieved via a set of prices (p*) whereby markets clear simultaneously:

$$E_i = E_i\,(p^*_1, p^*_2, \ldots p^*_n) = 0 \qquad \text{for all i.} \qquad (2)$$

For a multi-region model incorporating international trade, excess demand is modified to account for exports (X) and imports (M) in region j (j = 1, 2, ..., m):

$$E_{ij} = (D_{ij} + X_{ij}) - (S_{ij} + M_{ij}), \qquad (3)$$

and at equilibrium,

$$E_{ij} = E_{ij}\,(p^*_{11}, \ldots, p^*_{n1}, p^*_{12}, \ldots, p^*_{n2}, \ldots, p^*_{1m}, \ldots, p^*_{nm}) = 0$$

$$\text{for all i and all j} \qquad (4)$$

This representation highlights the interdependence between markets (and regions), and shows how a change in price in one market will, at least in principle, have an impact on all other markets. Indeed, the Walrasian (GE) perspective on the economic system has been described as one in which 'no blade of grass can move without altering the position of the stars' (Barber, 1967, p. 201).

The concepts employed in GE permeate much of our economic thinking, for example, production possibility frontiers, indifference curves, relative prices and terms of trade. Furthermore, recognition is often given to the potential role of GE in modelling exercises: "General equilibrium rather than partial equilibrium relationships should be emphasised in the structure of a policy model" (Rausser and Just, 1982, p. 765). However, there is relatively little in the agricultural economics literature that addresses the economy-wide effects of agricultural policies. In the UK, there has been the occasional foray into Leontief input-output type analysis (see, for example, Roberts, 1994), but in terms of GE modelling this represents only a half-way house, suffering from the limitations of exogenous final demand, perfectly elastic factor supplies, an absence of behavioural relationships and an inability to demonstrate welfare effects. Elsewhere, principally in Australia, North America and Continental Europe, a limited amount of work has been undertaken using AGE models to analyse the economy-wide effects of agricultural policy issues, including tax preferences (Hertel and Tsigas, 1988), unilateral liberalisation of the agricultural sector (Stoeckel *et al*, 1989), interregional effects of farm subsidies (Kilkenny, 1993) and multilateral trade negotiations (Nguyen, Perroni and Wigle, 1993; and OECD, 1993). An overview of the use of AGE modelling in agricultural policy analysis is provided by Hertel (1991).

There are a number of reasons why GE modelling of the CAP, and of agricultural policies in general, has not flourished. First, an argument in favour of partial equilibrium (PE) is that since agriculture in industrial countries accounts for only a small share of GDP and a similar share of (non-land) resources, all linkages with the non-agricultural sectors of the economy can be ignored and full advantage taken of the *ceteris paribus* assumption. The validity of this approach is demonstrated formally by Hertel (1990) and adopted by Tyers and Anderson (1988, p.198) in their multi-region PE modelling of agricultural trade liberalisation: "... since agriculture typically accounts for less than five per cent of GDP and a not much larger share of trade in industrial countries, a partial equilibrium approach is not inappropriate ...". In analysing a single market, an extreme version of this approach would be to reduce (1) to:

$$E_i = E_i\ (p_i). \qquad (5)$$

Second, PE models allow for greater attention to detail. For example, Anderson and Tyers (1993, p. 196) argue that "... the main advantage of the simpler partial-equilibrium models [is] their greater commodity and country detail and the greater ease with which dynamic and stochastic features can be included".

Third, an argument against the use of GE is that resultant models, other than the most basic, are perceived as too complex, generating 'black box' results. In addition, they are often seen as unmanageable and highly demanding in terms of data input and computing requirements. Whilst there is legitimacy in some of these concerns, recent developments in computing and in the availability of standardised modelling frameworks have eased the situation considerably. This suggests that AGE modelling could become more of a routine exercise in assessing economy-wide effects of economic policies (Hertel, 1991 and Stoeckel *et al*, 1989).

In some cases, PE and GE models yield results that are contradictory. For example, Tyers and Anderson (1988) showed that net economic welfare in developing countries would be expected to fall, in both the short run and long run, following agricultural trade liberalisation in industrial countries. This was due to a rise in international food prices, with consumers' losses outweighing farmers' gains.

Although substantiating results from similar PE models, this outcome was called into question by GE results which suggested developing countries as a group might gain from such liberalisation (see, for example, Burniaux and Waelbroeck, 1985 and Loo and Tower, 1989). Noting that "Reconciling these differences would be helpful ...", Anderson and Tyers (1993, p. 196) were able to reverse the original outcome for developing countries by adjusting their PE model to reflect the importance of previously ignored effects emanating from non-agricultural sectors, namely manufacturing protection and currency overvaluation. Although the results from this exercise are not strictly comparable with their earlier estimates, owing to different forecast years, these adjustments transformed the net economic welfare position of developing countries from a sizeable loss (1985 US $ 14,000 million) into a sizeable gain (11,000 million).

A range of PE and GE models, with reference to agricultural trade liberalisation, are documented in Goldin and Knudsen (1990), and comparisons of the two approaches are provided by Hertel (1990 and 1992) and de Janvry and Sadoulet (1987).

3. The Global Trade Analysis Project (GTAP) Model

Depending on its use, the design of an AGE model will vary in terms of sectoral coverage, country coverage (in the case of a multi-region model), level of aggregation, behavioural assumptions, choice of functional forms, etc. To date, taxation and trade have been two key areas that AGE modellers have tackled. In concentrating on the latter, this section highlights salient features of the Global Trade Analysis Project (GTAP) model (see Hertel, 1996).

3.1 Regions and sectors

In its disaggregate form the GTAP model identifies 24 regions, each of which produces 37 tradable commodities (and a capital good) for use in final demand or as intermediate inputs. All firms within a sector produce a single commodity and there is thus a one-for-one relationship between sectors and commodities. There are also private households supplying three endowment commodities (primary factors). Of these, labour and capital are treated as perfectly mobile between sectors, whilst land is less than perfectly mobile. Consequently, returns to labour and capital are uniform across sectors, but the return to land is sector-specific. The model identifies three forms of final demand: private household expenditures, government expenditures and savings. In addition, a global transport sector provides services for the movement of commodities between regions, and a global banking sector intermediates between savings and investment.

3.2 Data input

There are three principal sets of data input: domestic input-output tables for the regions; bilateral gross trade flows; and protection data, expressed in the model as *ad valorem* price wedges. In addition, parameter values are 'borrowed' from the literature or calibrated from the base year data (which are assumed to reflect equilibrium conditions). The model recognises various prices and distortions (i.e., taxes and subsidies) within markets. These are described in Appendix 1.

3.3 Behavioural assumptions

The model incorporates standard assumptions regarding neo-classical economic behaviour (profit maximisation by firms, utility maximisation by consumers and full employment). Production activities incorporate constant-returns-to-scale technologies and, as is common in models of this type, are separable and 'nested' in a hierarchical structure. Firms' revenues must be exhausted on costs of intermediate inputs and primary factors to ensure zero profits. A utility function is used to distribute regional income across the three forms of final demand. As with the production activities, consumer preferences are 'nested'. Within the hierarchical production and consumption structures, import demand for tradable commodities (intermediate inputs for firms and final demand for private households and governments) is modelled in an Armington framework. That is, products are treated as imperfect substitutes and differentiated by region of origin, accommodating gross (intra-industry) flows in the trade data. Thus, the model is one of heterogeneous products. (The consumption and production structures are outlined in Appendix 2.)

3.4 Closure, shocks and counterfactual equilibrium

Closing the model involves determining the exogenous and the endogenous variables. In the standard GE closure, all market prices and outputs (of the produced commodities) are endogenous. Supplies of the endowment commodities are exogenous, as are all taxes and subsidies. To use the model for simulation, the initial 'benchmark' equilibrium is subjected to a shock (e.g., abolition of the CAP) and a new 'counterfactual' equilibrium is derived.[1] Levels of the endogenous variables are then

[1] The model is solved in linearised form using GEMPACK (Harrison and Pearson, 1994).

compared between the two equilibria, making the analysis one of comparative statics. Endogenous price changes in the model are computed in relative terms, i.e., the prices in n-1 markets are expressed relative to price in the n^{th} market (the numeraire).

The standard GTAP model can be criticised for its conventional CGE structure, which fails to capture, for example, the presence of imperfect competition, increasing returns or dynamic effects. To its credit, however, it offers a wide coverage of sectors and countries and is flexible in that these can be easily aggregated, according to interests and needs, to form models of more manageable proportions. One such aggregation is used here to analyse the domestic and international consequences of the CAP.

3.5 Simulating Abolition of the CAP

In this application, the counterfactual equilibrium simulates complete abolition of the CAP, i.e., the EU is assumed to operate under conditions of free trade in agricultural and food commodities. Comparison with the benchmark equilibrium then allows differences in the endogenous variables to be attributed to the CAP. The model is calibrated to 1992 data bases, which are aggregated into seven regions and 10 sectors (tradable commodities). The seven regions are: the European Union (EU); the United States of America and Canada (USCAN); Australia and New Zealand (AUSNZ); the high income East Asian economies of Japan, Republic of Korea, Singapore, Hong Kong and Taiwan (HIEA); Latin America (LATAM); Eastern Europe and the Former Soviet Union (EEFSU); and the rest of the world (ROW). The 10 sectors, reflecting an agriculture and food bias, are: grains; non-grain crops; livestock; meat products; milk products; other food; other primary products; manufacturing; services; and construction and utilities.

The shocks to output subsidies, import levies and export subsidies in the EU, necessary to simulate elimination of the CAP, are given in Table A2 of Appendix 3.

4. Results

4.1 Milk Products

The GTAP model is one of heterogeneous products and consequently its behaviour under the no-CAP simulation is rather different from what would be expected with a homogeneous products model. To illustrate this behaviour it is instructive to focus on a single sector within the model. Accordingly, changes in the quantity, price and value (revenue / expenditure) of domestically produced and imported *milk products* in the EU are shown in Table 1. The abolition of EU import levies leads to a fall of 55 per cent in the price of imported milk products. In response, consumers (private households and firms) substitute imports for domestically produced milk products, the degree of substitution being determined by the Armington elasticities (refer to Appendix 2). As a result, the quantity of milk products imported by the EU rises (from a very low base) by 2000 per cent (private households' demand +2500 per cent; firms' demand +1300 per cent). With the halving in import price, the rises in expenditure on imports are roughly half of the quantity changes (see Table 1).

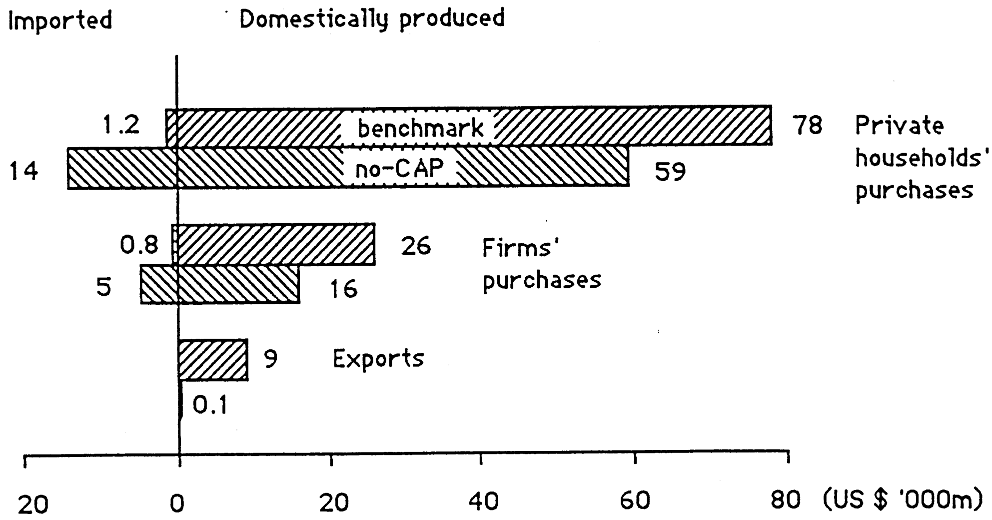
With consumers purchasing more imports, demand falls for domestically produced milk products and EU producers respond in cutting output by 34 per cent. This comprises a fall of 28 per cent in domestic sales (private households -25 per cent; firms -39 per cent) and virtual elimination of exports, the price of which nearly doubles following removal of export subsidies. In the new long-run equilibrium, the price of domestically produced milk products shows almost no change. This may seem *prima facie* a rather odd outcome. It can be explained by movements of roughly similar magnitude in both the demand for and supply of EU milk products, such that although economic activity in the sector is greatly reduced, price remains largely unaltered.

Table 1 Percentage Changes in Quantity, Price and Value of Milk Products in the EU under the no-CAP simulation

	Quantity	Price	Value
EU imports	2000	-55	850
- by private households	2500	-55	1100
- by firms	1300	-55	540
EU domestic output	-34	≈0	-34
- domestic sales	-28	≈0	-28
- to private households	-25	≈0	-25
- to firms	-39	≈0	-39
- exports	-99	92	-98

The value of domestic and imported milk products in the benchmark and counterfactual equilibria are shown in Figure 1. The share of imports in private households' total expenditure on milk products rises to a fifth under the no-CAP simulation. For firms, the import share rises to a quarter.

Figure 1 Value of Milk Products in the EU under the benchmark equilibrium and no-CAP simulation.



4.2 Prices

Estimates of the changes in supply prices for all produced commodities (10 tradables plus capital goods) and the three endowment commodities of land, labour and capital, in each of the seven regions, under the no-CAP simulation, are shown in Table 2. Within the EU, all prices fall, except for milk products. The falls in EU agricultural prices are considerably less than those reported by Harvey and Thomson (1985), whilst the fall in the return to land (-69 per cent) is larger than that estimated by Stoeckel and Breckling (1989) and McDonald (1990). In other regions, all prices rise, with the largest increases recorded for agricultural and food products and land.

Table 2 Abolition of CAP: Percentage Changes in Supply Prices

	EU	USCAN	AUSNZ	HIEA	LATAM	EEFSU	ROW
Grains	-8	4	7	3	6	9	5
Non-grain crops	-8	5	8	4	8	11	6
Livestock	-6	3	9	2	7	11	5
Meat products	-1	3	7	2	5	7	4
Milk products	+	2	6	2	5	6	4
Other food	-5	2	4	2	4	3	3
Other primary products	-3	1	3	1	3	2	1
Manufacturing	-3	1	3	1	2	2	1
Services	-3	1	3	1	3	2	1
Construction & utilities	-3	1	3	1	3	2	2
Capital goods	-2	1	3	1	2	1	1
Land	-69	34	27	12	26	48	22
Labour	-3	1	4	1	3	2	2
Capital	-3	1	3	+	3	2	1

+ = positive change of less than 1 per cent.

Note: all price changes are relative to the price of savings (the numeraire).

4.3 Output

Within the EU, large falls in the output of agricultural and food products lead to increases in other sectors, including a five per cent rise in manufacturing output and a two per cent rise in services (Table 3). Output of non-grain crops in the EU is virtually eliminated. Elsewhere, agricultural and food production is generally higher, with the largest increase in output of grain occurring in USCAN, and a doubling in output of milk products in AUSNZ and the ROW. Manufacturing and services output falls in all regions other than the EU.

Table 3 Abolition of CAP: Percentage Changes in Sectoral Output

	EU	USCAN	AUSNZ	HIEA	LATAM	EEFSU	ROW
Grains	-34	13	-2	1	2	4	2
Non-grain crops	-89	15	7	7	14	12	12
Livestock	-23	9	11	4	6	28	10
Meat products	-15	3	20	2	10	17	6
Milk products	-34	5	105	4	4	24	90
Other food	-3	+	-1	-	-2	1	-1
Other primary products	6	-1	-7	1	-4	-3	-2
Manufacturing	5	-1	-4	-1	-3	-3	-3
Services	2	-	-1	-	-	-	-1
Construction & utilities	1	-	+	+	+	-	+
Capital goods	+	+	+	+	+	+	+

+/- = positive/negative change of less than 1 per cent.

4.4 Trade

Changes in volumes of exports and imports of tradable commodities are presented in Tables 4 and 5. Exports of grain, non-grain crops, meat and milk products from the EU are eliminated. All other sectors in the EU record substantial increases in exports, including manufacturing (17 per cent) and services (10 per cent). In total, the volume of EU exports increases by 13 per cent. Total exports from other regions show little change, although their composition alters markedly in favour of agricultural and food products. (Although not reported here, percentage changes in bi-lateral trade flows are more pronounced.)

Table 4 Abolition of CAP: Percentage Changes in Volume of Exports

	EU	USCAN	AUSNZ	HIEA	LATAM	EEFSU	ROW
Grains	-100	34	-4	237	41	11	71
Non-grain crops	-99	85	34	135	76	87	94
Livestock	29	138	-48	131	-9	331	211
Meat products	-98	46	46	25	174	203	141
Milk products	-99	251	259	187	82	325	1078
Other food	32	-5	-12	-3	-15	-15	-12
Other primary products	18	-	-9	2	-8	-5	-2
Manufacturing	17	-4	-13	-2	-10	-9	-6
Services	10	-2	-7	1	-6	-6	-4
Construction & utilities	18	-3	-12	1	-9	-6	-5
Total	13	+	1	-1	1	2	1

+/- = positive/negative change of less than 1 per cent.

The EU experiences large increases in imports of grains, non-grain crops, livestock, and meat and milk products (albeit from small base volumes), and reductions in all other sectors. Overall, total volume of EU imports increases by 8 per cent. Elsewhere, changes in imports of agricultural and food products are mixed, although all regions import more manufactured goods.

Table 5 Abolition of CAP: Percentage Changes in Volume of Imports

	EU	USCAN	AUSNZ	HIEA	LATAM	EEFSU	ROW
Grains	540	4	12	-3	5	12	-5
Non-grain crops	220	-6	4	-3	9	3	-11
Livestock	370	1	18	-8	24	27	1
Meat products	350	-9	4	-6	-2	-23	-30
Milk products	2000	-39	5	-21	-26	-46	-23
Other food	-19	4	9	2	6	11	9
Other primary products	-5	-1	+	-1	-	-	-1
Manufacturing	-7	2	4	+	3	6	3
Services	-6	1	5	-	4	5	4
Construction & utilities	-6	1	4	-1	3	2	2
Total	8	1	4	-	3	5	2

+/- = positive/negative change of less than 1 per cent.

At world level, elimination of the CAP results in minimal changes in supplies of tradable commodities, but substantial increases in the volume of agricultural and food products traded (Table 6). With negligible changes in other sectors, total world trade rises by 3 per cent.

Table 6 Abolition of CAP: Percentage Changes in Volume of World Supplies and World Exports

	Supplies	Exports
Grains	+	23
Non-grain crops	-6	71
Livestock	-1	95
Meat products	-	51
Milk products	-2	140
Other food	-1	+
Other primary products	+	-2
Manufacturing	-	+
Services	+	2
Construction & utilities	+	-1
Total		3

+/- = positive/negative change of less than 1 per cent.

4.5 Welfare

It is characteristic that structural changes (resource use, output, exports, imports) tend to dominate the results from AGE models. In contrast, welfare impacts are generally small. This "represents one of the robust properties of [these] models. ... In the long run, with flexible prices and all factors fully employed, market economies appear able to substitute around most problems and distortions" (Robinson, 1990, pp. 206-9). Estimates of changes in welfare following abolition of the CAP are shown in Table 7. The EU suffers a deterioration in its terms of trade, but this loss is outweighed by efficiency gains from improved allocation of resources, and the net outcome is an improvement in utility of 0.8 per cent (US $ 49,000 million). This estimate can be compared to the net cost of the CAP, reported by Harvey and Thomson (1985), of 0.5 per cent of GDP. For HIEA and EEFSU, the situation is reversed in that a terms of trade improvement is more than offset by increased efficiency losses. (The latter occur as a consequence of domestic distortions in these regions being increased following the price changes that result from abolition of the CAP.) The increase in utility is greatest for AUSNZ (1.2 per cent) and LATAM (0.7 per cent), with the world better off by US $ 75,000 million (0.4 per cent).

Table 7 Abolition of CAP: Changes in Welfare

Region	% change in		change in income
	Terms of Trade	Utility	(US $ million)
EU	-3.4	0.8	49,000
USCAN	0.9	0.1	2,900
AUSNZ	3.6	1.2	3,400
HIEA	0.2	-0.0	-270
LATAM	2.4	0.7	7,600
EEFSU	1.9	-0.1	-590
ROW	1.6	0.5	13,000
World		0.4	75,000

5. Summary and Conclusions

This paper has examined the domestic and international economy-wide costs of the CAP within a general equilibrium framework provided by the GTAP model. Using complete abolition of the CAP as the counterfactual equilibrium, large falls in output and exports from the agri-food sectors in the EU lead, *inter alia*, to increases in manufacturing and services output (5 and 2 per cent, respectively) and exports (17 and 10 per cent). In other regions of the world, output and exports in the agri-food sectors generally rise, accommodated by falls in the level of manufacturing and services activity. The overall shuffling of global resources causes significant structural changes to the economies in all regions, particularly with respect to trade flows. However, welfare impacts, resulting from efficiency and terms of trade effects are smaller in comparison, with an improvement for the EU of 0.8 per cent and for the world of 0.4 per cent.

In that it has the potential to widen the debate surrounding issues of agricultural policy and trade reform, AGE modelling is deserving of more attention. It accommodates the impact of agricultural policies on the non-agricultural sectors of an economy and, similarly, the impact on agriculture of changes in the non-agricultural sectors. In a broader context, international effects can be captured through trading links within a global general equilibrium setting. Although overshadowed hitherto by partial equilibrium analysis, growing interest in AGE models has been given added stimulus by the Uruguay GATT Round. With recent developments, use of such models may soon become routine. In short, "... general equilibrium has been one of the economics profession's finest contributions to the human intellectual heritage and should certainly be exploited for all its worth" (Winters, 1990, p. 453).

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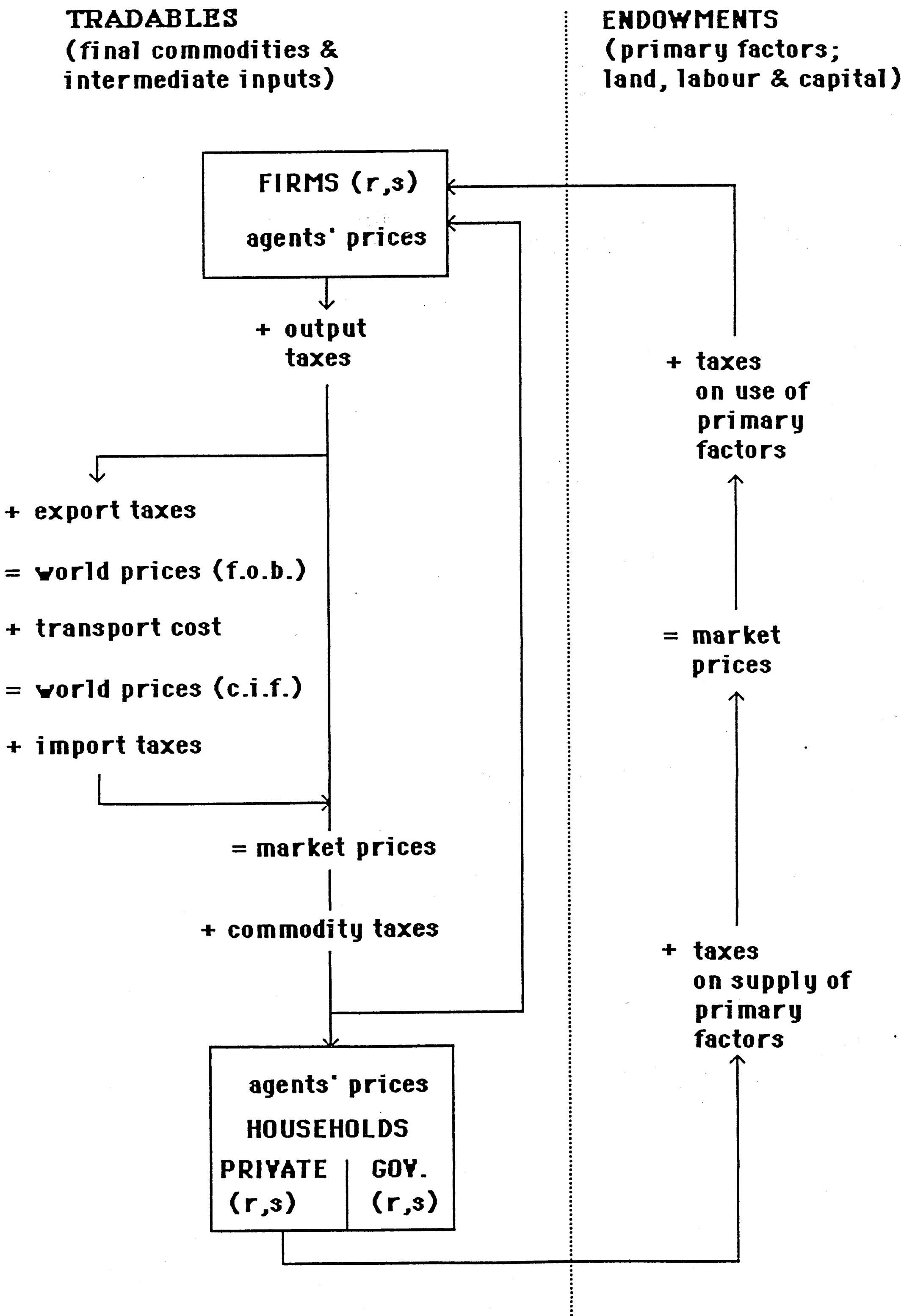
Appendix 1

Prices and Taxes (Subsidies) in the GTAP Model

Figure A1 highlights the prices and taxes (or subsidies) identified in the GTAP model. A firm in region r sells its good at the agents' price. This good may then be subject to an output or producer tax, yielding a market price if it is for domestic use. If, however, the good is destined for a foreign market it may be subject to an export tax, yielding a world price, free on board (f.o.b.). Addition of the transport margin gives a world price including cost, insurance and freight (c.i.f.). As this good enters the foreign market it may be subject to an import tax, which yields a market price in region s. In whichever region, the good may then be subject to a commodity or consumer tax. This yields the agents' price paid by private and government households (if the good is destined for final demand) and by firms (if the good is to be used as an intermediate input).

Private households in region r supply, at agents' prices, the endowment commodities - land, labour and capital - to firms in region r. These commodities may be subject to primary factor supply taxes, yielding market prices, and also to primary factor usage taxes, yielding the agents' prices paid by firms.

Figure A1 Prices and Taxes (Subsidies) in the GTAP Model



Appendix 2

Consumption and Production Structures in the GTAP Model

Consumption

At level 1 (top of Figure A2), a Cobb-Douglas function specifies regional utility (*u*) over the three forms of final demand: private households (*up*), government (*ug*) and savings (*qsave*). At level 2, *up* is distributed across composite tradables (*qp*) according to a constant difference elasticity function, and *ug* is distributed across composite tradables (*qg*) according to a Cobb-Douglas function. At level 3, *qp* is a CES function of the domestic tradable (*qpd*) and a foreign composite tradable (*qpm*). At level 4, *qpm* is a CES function of imported tradables (*qps*). (Although not shown in Figure A2, levels 3 and 4 apply identically to *qg*.)

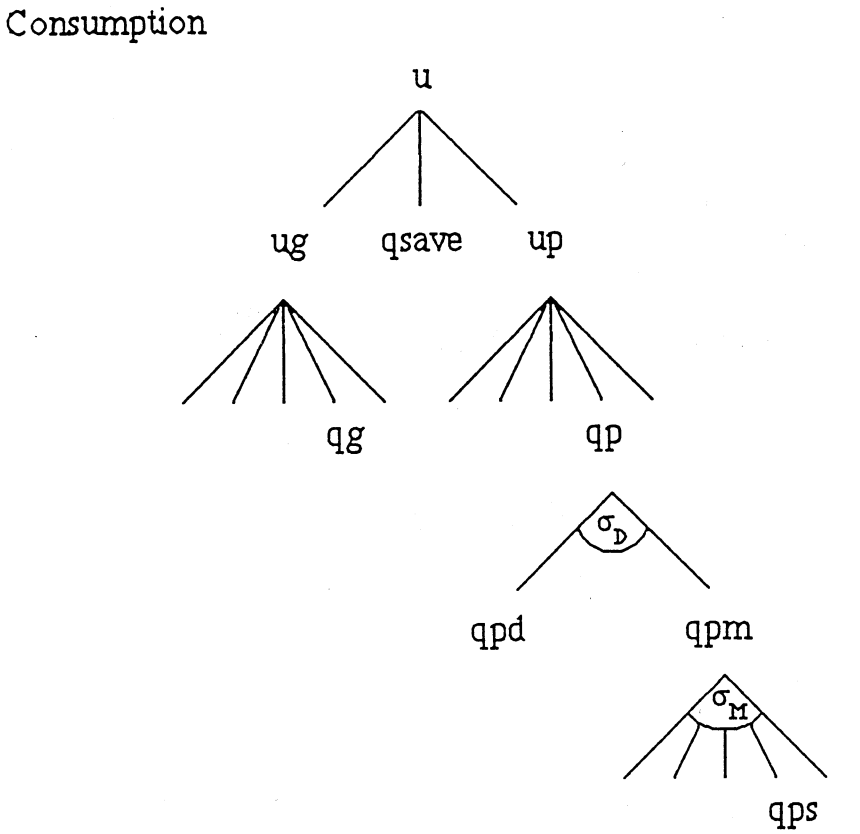
Production

At level 1, sectoral output (*qo*) uses fixed proportions of value-added (*qva*) and composite intermediates (*qf*). At level 2, *qva* is a CES function of land (*La*), labour (*L*) and capital (*K*), and *qf* is a CES function of the domestic intermediate (*qfd*) and a foreign composite intermediate (*qfm*). At level 3, *qfm* is a CES function of imported intermediates (*qfs*).

Armington Elasticities

The Armington elasticities of substitution, σ_D and σ_M, which are assumed to be equal across all uses (firms and private and government households), are given in Table A1. (For grain, non-grain crops, livestock, meat products and milk products, these elasticity values are twice those in the GTAP base data set, to reflect the greater homogeneity of agricultural and food products. The other elasticity values are as derived from the GTAP base data set.)

Figure A2 Consumption and Production Structures in the GTAP Model



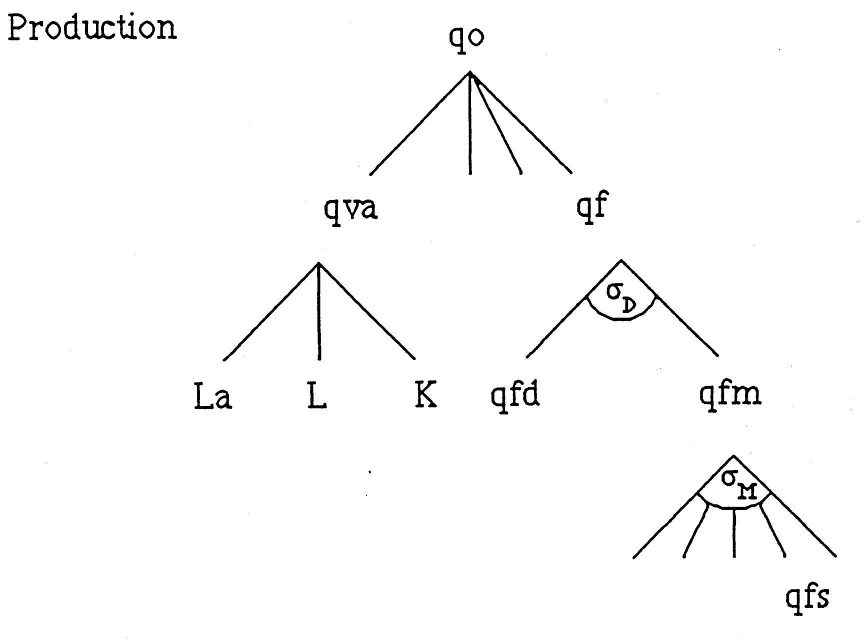


Table A1 Elasticities of Substitution

Sector	σ_D	σ_M
Grain	4.40	8.80
Non-grain crops	4.40	8.80
Livestock	5.58	10.7
Meat products	4.40	8.80
Milk products	4.40	8.80
Other food	2.45	4.90
Other primary products	2.80	5.60
Manufacturing	2.80	6.16
Services	1.90	3.80
Construction & utilities	2.01	4.52

Appendix 3

Table A2 Shocks used to simulate Abolition of the CAP

a) EU output subsidies: % change*

Grain	-4.4
Non-grain crops	-41.5
Livestock	-8.4
Meat products	-0.2
Milk products	+0.4

b) EU import levies: % change*

From:	USCAN	AUSNZ	HIEA	LATAM	EEFSU	ROW
Grain	-41.9	-47.6	-53.4	-44.7	-40.0	-49.9
Non-grain crops	-36.9	-36.9	-36.9	-36.9	-36.9	-36.9
Livestock	-35.6	-8.4	-35.2	-27.1	-35.6	-33.1
Meat products	-35.9	-35.9	-35.9	-35.9	-35.9	-35.9
Milk products	-57.1	-57.1	-57.1	-57.1	-57.1	-57.1

c) EU export subsidies: % change*

To:	USCAN	AUSNZ	HIEA	LATAM	EEFSU	ROW
Grain	-71.5	-70.8	-68.6	-68.3	-69.3	-68.9
Non-grain crops	-23.3	-23.3	-23.3	-23.3	-23.3	-23.3
Livestock	-0.7	-0.4	-0.6	-0.7	-0.7	-0.7
Meat	-44.8	-44.8	-44.8	-44.8	-44.8	-44.8
Milk	-47.7	-47.7	-47.7	-47.7	-47.7	-47.7

* to power of the tariff equivalent.

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