DEPARTMENT OF
AGRICULTURAL ECONOMICS & FOOD MARKETING

DISCUSSION PAPER

University of Newcastle upon Tyne

DP 4/95 **June 1995**

CGE Modelling of the CAP: Trade Elasticities, Structural Effects and Welfare

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Price £5.00

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Abstract

This paper reports on an application of a multi-region CGE model in which the economy-wide structural and welfare effects of the CAP are assessed with reference to the trade (substitution) elasticities that determine the mix of domestic and imported goods. Within the range of elasticity values used, the manufacturing sector in the EU experiences levels of output up to 5 per cent lower, and levels of exports up to 16 per cent lower, as a result of the CAP. Activity in the service sector is similarly constrained. With regard to welfare, although deterioration of the EU's terms of trade is stable, a quadrupling of elasticity values is shown to result in a near ten-fold increase in utility.

1. Introduction

Structural changes (outputs, imports, exports) tend to dominate the results from computable general equilibrium (CGE) 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). Both structural changes and welfare impacts in CGE models are a function of the transference of resources between sectors, which in turn is dependent on the ease of substitution in production and consumption. Substitution parameters therefore play an important part in determining the 'costs' of policy-induced distortions. This paper reports on an application of a multi-region CGE model in which the economy-wide

[1] The author would like to thank Phil Dawson for commenting on an earlier version of the paper.

structural and welfare effects of the Common Agricultural Policy (CAP) are assessed, with reference to the substitution (trade) elasticities that determine the mix of domestic and imported goods. The model is described in Section 2, the application and simulation results are contained in Section 3 and the main conclusions are presented in Section 4.

2. The GTAP Model

General equilibrium is concerned with interdependence between markets in an economic system. All markets are treated as endogenous and an equilibrium solution is achieved via a set of prices whereby markets clear simultaneously. The interdependence between markets (and countries/regions in a global economic system) means that a change in price in one market will, at least in principle, have an impact on all other markets. Depending on its intended use, the design of a CGE model will vary in terms of sectoral coverage, regional coverage, level of aggregation, behavioural assumptions, choice of functional forms, etc. This section highlights salient features of the Global Trade Analysis Project (GTAP) CGE model (see Hertel, 1995). An application of a version of this model then follows.

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 perfectly mobile between sectors, whilst land (used only in agricultural production) 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.

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 (e.g., market, world) and distortions (e.g., producer subsidies, import tariffs) within markets.

Behavioural assumptions

The model incorporates standard assumptions regarding neo-classical economic behaviour (profit maximisation by firms and utility maximisation by consumers, under conditions of perfect competition with factors fully employed). 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 I.

Closure, shocks and counterfactual equilibrium

Closing the model involves determining the exogenous and the endogenous variables. 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.[2] Levels of the endogenous variables are then compared between the two equilibria, making the analysis one of comparative statics.

The standard GTAP model, with its conventional CGE structure, fails to capture any increasing returns in production or dynamic effects of capital accumulation. 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 reported in the following section.

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

3. Application and Simulation Results

An application of the GTAP model is used to assess the structural and welfare effects of the CAP, with reference to the trade (Armington) elasticities which govern the sourcing of imports (σ_M) and the extent of substitution between domestic and foreign goods (σ_D). 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 solution allows differences in the endogenous variables to be attributed to the CAP.

The model is calibrated to 1992 data bases, which for the purpose of this simulation 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 production subsidies, import levies and export subsidies in the EU, necessary to simulate elimination of the CAP, are given in Table 1. Seven simulations are reported. In the 'control' simulation, the Armington elasticities are set at their base values (given in Table A1 of Appendix I). Two 'extreme' simulations embody elasticities which are, respectively, half and double these base values. In the remaining four simulations elasticity values for σ_D and σ_M are halved (doubled) independently, to focus on their separate effects. Thus, these four simulations lie between the 'extremes' and the 'control'. All other data input remains unaltered.

Table 1 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	-21.7	-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.

Structural Results

Following simulated abolition of the CAP, estimates of structural changes (EU output, imports and exports and world exports) in the five agri-food sectors, manufacturing and services, under the seven sets of trade elasticities, are shown in Table 2. Using the base set of substitution elasticities (simulation IV), falls in output of agriculture and food products in the EU are countered by output increases in manufacturing (2.7 per cent) and services (1.1 per cent). These can be considered as 'costs' of the CAP not explicitly identified in the more usual partial equilibrium analyses. In the agri-food sectors of the EU, the falls in output are associated with concomitant increases in imports and near elimination of exports. In manufacturing and services, EU imports decrease by 4.1 per cent and 3.3 per cent, and exports increase by 10 per cent and 5.9 per cent, respectively. Overall, total EU imports fall by 3.8 per cent, while total EU exports rise by 6.2 per cent. At world level, under the base elasticities, abolition of the CAP causes substantial increases in trade of non-grain crops (50 per cent) and livestock (35 per cent), a small increase in services trade (1 per cent), but a negligible change in trade of manufactures.

Halving the Armington elasticities dampens all of these structural changes but to varying degrees (see simulation I of Table 2). Manufacturing output in the EU now increases by 1.6 per cent, and services output by 0.6 per cent. The increase in total EU imports (1.1 per cent) is less than a third of that under the base elasticity values, whilst the increase in total EU exports (3.1 per cent) is exactly halved, although exports of grain are still virtually eliminated.

Table 2 Structural Effects with Abolition of the CAP

(% quantity change)

Simulation	I	II	III	IV	V	VI	VII
σ_D (x base values)	0.5	0.5	1	1	1	2	2
σ_M (x base values)	0.5	1	0.5	1	2	1	2
EU OUTPUT							
grains	-15	-16	-19	-20	-21	-34	-35
non-grain crops	-34	-35	-58	-60	-61	-89	-90
livestock	-6.0	-6.9	-9.6	-11	-12	-22	-24
meat products	-5.3	-6.3	-7.5	-8.3	-8.8	-15	-15
milk products	-8.1	-10	-13	-14	-15	-34	-35
manufacturing	1.6	1.7	2.6	2.7	2.8	4.4	4.5
services	0.6	0.7	1.1	1.1	1.2	1.8	1.9
EU IMPORTS							
grains	74	75	190	190	200	570	590
non-grain crops	84	84	160	160	160	220	220
livestock	55	57	130	140	160	350	410
meat products	59	60	140	140	150	370	390
milk products	150	150	460	480	490	2100	2100
manufacturing	-2.7	-1.6	-5.7	-4.1	-2.3	-8.9	-6.2
services	-2.1	-1.2	-4.8	-3.3	-1.7	-7.5	-4.9
total	1.1	2.1	2.1	3.8	5.6	6.0	9.2
EU EXPORTS							
grains	-90	-99	-90	-99	-100	-99	-100
non-grain crops	-76	-94	-75	-94	-100	-92	-99
livestock	-11	-22	-6.3	-13	-30	7.2	8.5
meat products	-64	-88	-68	-88	-99	-89	-99
milk products	-62	-87	-70	-89	-99	-90	-99
manufacturing	6.2	8.0	7.7	10	12	13	16
services	3.7	4.1	5.2	5.9	6.2	8.2	9.2
total	3.1	3.9	4.6	6.2	7.7	9.2	12
WORLD EXPORTS							
grains	-2.0	0.7	-0.3	4.5	7.2	19	24
non-grain crops	24	25	47	50	52	68	72
livestock	13	14	33	35	39	89	100
meat products	2.5	5.2	10	15	21	46	57
milk products	-9.6	-3.4	-0.3	11	27	120	160
manufacturing	0.0	0.0	0.1	0.1	0.0	0.3	0.1
services	0.4	0.5	0.8	1.0	1.1	1.6	1.8
total	0.5	0.6	1.1	1.2	1.5	2.7	3.1

Note: See Table A1 of Appendix I for base values of σ_D and σ_M.

Doubling the base elasticity values exaggerates the shuffling of resources and the associated structural changes (see simulation VII of Table 2). Output of non-grain crops in the EU is all but eliminated and that of grain and milk products cut by over one third. Manufacturing and services output is increased by almost 5 per cent and 2 per cent, respectively. EU exports of grain, non-grain crops, meat and milk products are eliminated, with manufacturing exports higher by 16 per cent and exports of services higher by 9 per cent. At world level, there are now much larger increases in exports of agricultural and food products, although still no change in overall volume of trade in manufactured goods. Total world exports increase by 3.1 per cent, over two and a half times greater than under the base elasticity values.

The results from simulations II, III, V and VI indicate that volumes of *EU output* and *imports*, and *world exports*, are more sensitive to σ_D than to σ_M. For example, simulations III and V (which encompass a quadrupling of values for σ_M whilst holding values for σ_D constant at base levels) produce results akin to those of simulation IV (the 'control'). Likewise, simulation II produces results akin to those of simulation I, while simulation VI produces results akin to those of simulation VII, despite a doubling of the values for σ_M in both cases. In contrast, volumes of *EU exports* are more influenced by σ_M, particularly at the lower elasticity values. For example, the changes in EU exports under simulation II are much more akin to those under simulation IV, and those under simulation III more akin to those under simulation I, despite a doubling of the values for σ_D in each case.

The changes in each of the endogenous variables in Table 2 exhibit the same signs under all simulations, bar three cases. For world exports of grain, the changes range from -2.0 per cent to +24 per cent, as elasticity values are increased. For world exports of milk products, the changes range from -9.6 per cent to +160 per cent, again as elasticity values are increased. For EU exports of livestock, the changes range from -30 per cent to +9 per cent, although in this case the pattern is somewhat erratic.

Welfare Results

How do these varying degrees of structural change affect welfare? Estimates of changes in terms of trade and utility are given in Table 3. The EU's terms of trade decline by up to 2.1 per cent under the seven simulations. This deterioration occurs as a combination of a fall in the price of EU exports of manufactured goods and services and a rise in the price of food imports. However, these terms of trade losses are more than offset by efficiency gains, which are greater with the larger elasticities and heightened structural change. Thus, under the 'extreme' simulations (I and VII), a quadrupling of elasticity values is shown to result in utility in the EU increasing from 0.14 per cent (US $ 8000 million in 1992 prices) to 1.3 per cent (US $ 75000 million), a near ten-fold increase.

Resource movements globally mean that the world suffers a net loss of utility of between 0.11 per cent and 0.38 per cent as a result of the CAP, although some countries, notably major exporters of agricultural and food products, loose considerably more. (Although not reported here, the potential gains in utility for Australasia and Latin America are of comparable size to those for the EU.)

Table 3 Welfare Effects with Abolition of the CAP

(% change)

Simulation	I	II	III	IV	V	VI	VII
σ_D (x base values)	0.5	0.5	1	1	1	2	2
σ_M (x base values)	0.5	1	0.5	1	2	1	2
EU terms of trade	-1.7	-1.2	-2.1	-1.7	-1.2	-2.0	-1.6
EU utility*	0.14	0.33	0.39	0.57	0.77	1.1	1.3
World utility*	0.11	0.13	0.19	0.21	0.23	0.36	0.38

* Equivalent variation as percentage of initial income.
Note: See Table A1 of Appendix I for base values of σ_D and σ_M.

4. Conclusions

Within the confines of the CGE model used, it is clear that the structural and welfare effects of the CAP depend crucially on the size of the Armington elasticities, which govern the sourcing of imports and the extent of substitution between domestic and foreign goods. Structural effects are such that the manufacturing sector in the EU could claim its level of output is up to 5 per cent lower, and its level of exports up to 16 per cent lower, as a result of the CAP. The services sector could voice similar concerns. Simulation results show that EU output and imports are more sensitive to the extent of substitution between domestic and foreign goods (σ_D) than to switching between sources of imports (σ_M), but that the reverse applies to EU exports.

Decline in the agri-food sectors and concomitant expansion of manufacturing and services in the EU, which follow from simulated abolition of the CAP, cause resources in other countries to be reallocated. Globally, the volume of trade in manufactures remains unaffected in each of the simulations, but the higher elasticity values have a dramatic impact on changes in world exports of agricultural and food products, including a reversal of sign for grains and milk products. The net result is a small increase in global welfare, which is multiplied roughly two-fold by a doubling of the elasticities. With regard to welfare in the EU, although there is little variation in the worsening terms of trade, a quadrupling of elasticity values is shown to result in a near ten-fold increase in utility.

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Appendix I Consumption and Production Structures in the GTAP Model

Consumption

At level 1 (top of Figure A1), 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 A1, 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

Base values of 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.

Figure A1   Consumption and Production Structures in the GTAP Model

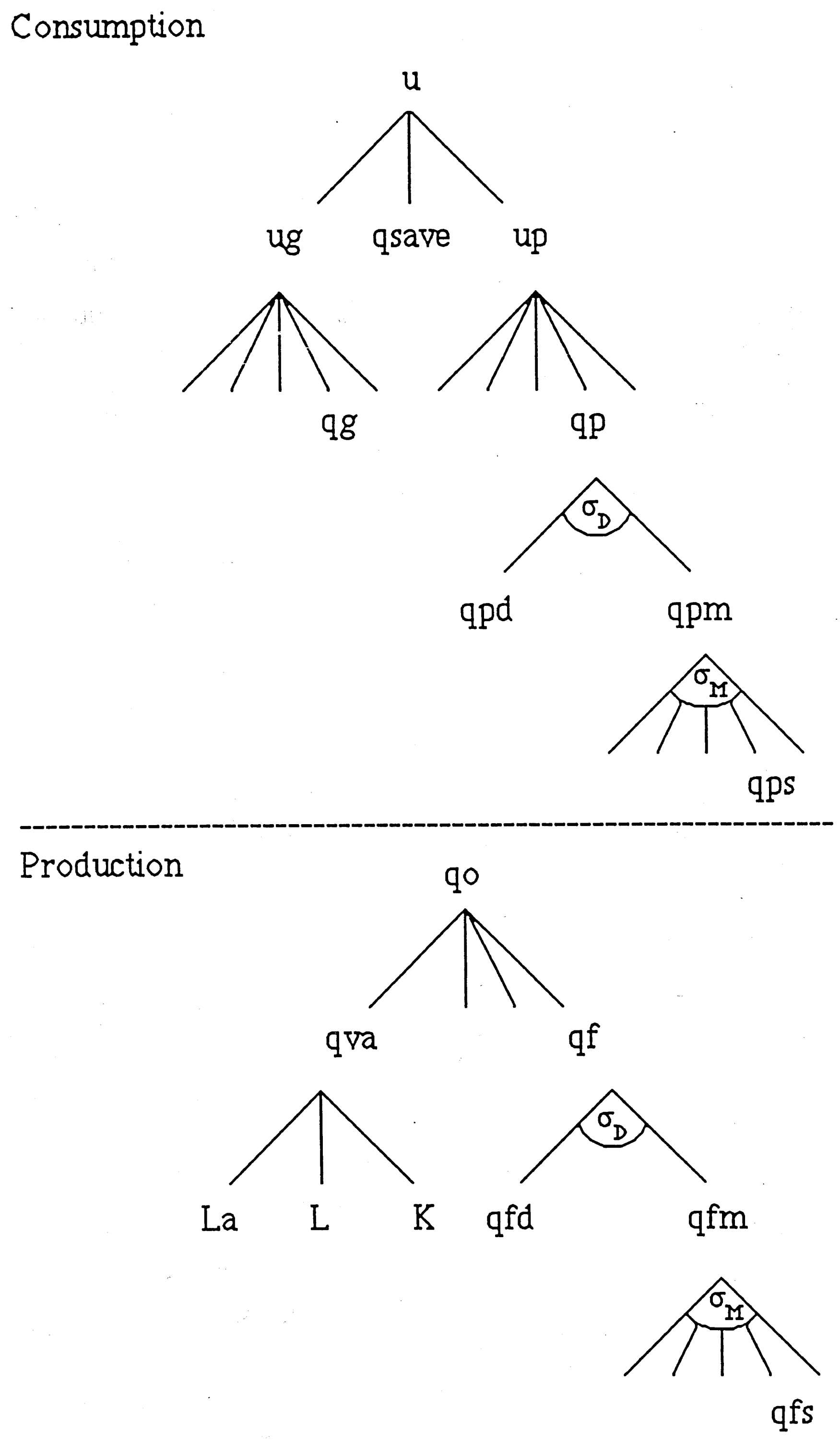

Table A1 Elasticities of Substitution

Sector	σ_D	σ_M
Grain	2.20	4.40
Non-grain crops	2.20	4.40
Livestock	2.79	5.36
Meat products	2.20	4.40
Milk products	2.20	4.40
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

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