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EUROPEAN COMMUNITY GRAIN AND MEAT  
POLICIES AND US RETALIATION:  
EFFECTS ON INTERNATIONAL PRICES,  
TRADE AND WELFARE

Kym Anderson and Rodney Tyers

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**EUROPEAN COMMUNITY GRAIN AND MEAT POLICIES**

**AND US RETALIATION:**

**EFFECTS ON INTERNATIONAL PRICES, TRADE AND WELFARE**

***Kym Anderson and Rodney Tyers***

***Department of Economics  
Research School of Pacific Studies  
Australian National University  
Canberra ACT 2601***

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## ABSTRACT

The extent to which policies in the EC reduce the level and increase the instability of international prices of grain and meat is estimated using a dynamic, stochastic, multicommodity simulation model. The results suggest that the EC is responsible for most of the instability in world grain and meat prices that is caused by policies of developed countries. It is also responsible for more than half of the international price-depressing effects of developed country policies. The trade and welfare effects of EC protection for the EC and for other major trading countries are also estimated from the model. Should real grain and meat prices within the EC be maintained through the 1980s, the results suggest that export surpluses will continue to grow. This scenario is compared with one in which real EC prices fall by 2 per cent annually through the 1980s. In the latter case the problem of export surpluses and hence the EC's budgetary problem are substantially reduced. The budgetary problem could also disappear for wheat if a producer levy is applied, but in such a case exports may still increase. Also estimated are the effects of retaliation by the United States in the form of a subsidy on its wheat exports. The adverse effects of such retaliation are much less for the EC than for the United States and are likely to be insufficient to force EC policy reform. Moreover, in per capita terms Canada and Australia are affected much more than the EC.

Key words: agricultural protection, European Community, US retaliation, international effects.

**EUROPEAN COMMUNITY'S GRAIN AND MEAT POLICIES**  
**AND US RETALIATION:**  
**EFFECTS ON INTERNATIONAL PRICES, TRADE AND WELFARE**

**INTRODUCTION**

There are numerous empirical studies which estimate the economic effects of the European Economic Community's (EC) common agricultural policy (CAP)<sup>1</sup>. However, most of these studies concentrate on intra-EC effects. Yet an important feature of the CAP is the use of variable import levies/export subsidies which reduce the mean and increase the variance of international food prices (while raising the average level and reducing the instability of agricultural prices within the EC). These international price effects, which have important implications for the trade and welfare of other countries, have received scant attention in the empirical literature, except in a single commodity setting<sup>2</sup>.

Moreover, with the steady increase in and stability of agricultural prices in Europe since the 1950s, EC production of many food items now exceeds EC consumption. The resulting surpluses can be disposed of only with the help of export subsidies. The major food exporting countries in North America, Australasia and elsewhere, which have been steadily squeezed out of the EC market over the past two decades because of EC protection growth, now face the prospect of losing some third-country markets because of subsidized exports from the EC. This has led to increased tension between the EC and traditional food exporters, particularly the United States. In response to this and the rising budgetary cost of export subsidies, the EC is considering the introduction of producer levies. Meanwhile, the United States has threatened to retaliate by subsidizing its own exports. Although such retaliation would benefit some food importing countries, it would have adverse effects not only for the EC (and the US) but also for other food exporters.

This paper seeks to quantify the international price, trade and welfare effects of EC grain and meat protection as of 1980, and to examine how those effects might change during the decade to 1990. Specifically, it seeks empirical answers to the following questions:

- to what extent have the level and instability of international prices for grain and meat, and the volume of international trade in those products, been affected by the CAP?

- . how large are these effects compared with those generated by the protection-cum-stabilization policies of Japan and of all developed market economies combined?
- . how would the price, trade and welfare effects differ in 1990 if real prices for grain and meat in the EC remained constant through the 1980s, as compared with a situation in which they declined at, say, 2 per cent annually?
- . how does the real price maintenance scenario compare with one in which a producer levy of, say, 2 per cent is applied to wheat in the EC?
- . what would be the international effects of US retaliatory export subsidies on wheat, say, if the EC maintains real price levels domestically?

After briefly summarizing the EC's recent trends in grain and meat, protection and self sufficiency, the paper presents answers to these questions by making use of a dynamic, stochastic simulation model involving five commodity groups: wheat, coarse grain, rice, ruminant meat and non-ruminant meat. The results show that around 1980 the CAP had depressed international prices for wheat, coarse grain and ruminant meat by about 15 per cent and it has increased the coefficient of variation of those prices by between 30 and 100 per cent. International trade in grain and meat has been correspondingly reduced. The CAP is shown to have a much larger impact on world prices and trade than the agricultural policies of all other developed countries combined. Even if real prices for grain and meat in the EC do not rise over the 1980s, export surpluses are projected to increase, along with the size of the budget needed to finance the inevitable export subsidies. On the other hand, if nominal prices grow at less than the rate of inflation (real prices fall 2 per cent per year), these problems at least would disappear, although rates of protection would still be considerable at the end of the 1980s for wheat, coarse grain and ruminant meat. The international price, trade and welfare effects of the latter scenario are considerably more favourable for food-exporting countries than if domestic EC prices are maintained in real terms through the 1980s. Should producer levies be introduced, the EC budgetary problem could be reduced but the effects on other food exporters may well be worsened. Finally, if the United States were to retaliate to the growth in subsidized exports from the EC by subsidizing US exports of wheat, say, then other grain exporters are made even worse off if this action is unsuccessful in changing EC policy, as seems likely.

**Table 1: Apparent Nominal Rate of EC Border Protection and EC**

**Self Sufficiency**

(per cent)

	Apparent Nominal Rate of Protection <sup>a</sup>			Self Sufficiency <sup>b</sup>	
	1968/69 to 1971/72	1972/73 to 1975/76	1976/77 to 1979/80	1968/69	1980/81
Wheat	102	16	94	94	126
Maize	64	19	89	45	66
Barley	83	14	85	103	113
Rice	85	-2	46	na	74
Oilseeds	59	4	73	na	na
Beef	47	36	98	90	104
Pork	34	25	42	100	101
Eggs	63	44	85	99	102
Milk (skim)	169	77	376	140	145
Butter	342	201	301	91	114
Sugar (white)	161	-14	110	95	125
<b>Weighted Average</b>	<b>118</b>	<b>59</b>	<b>154</b>		

a The percentage by which the EC variable levy at the port of entry of imports raises the c.i.f. import price.

b EC production as a percentage of EC consumption.

c Weights are based on the value of domestic agricultural production in 1976. Overall protection to the dairy industry is assumed to be the average for skim milk powder and for butter.

**Source:** Eurostat , The Agricultural Situation in the Community, Brussels, various issues.

### **RECENT TRENDS IN EC PROTECTION AND SELF SUFFICIENCY**

It is widely recognized that the variable import levy/export subsidy provisions of the CAP provide high levels of protection to farmers in the EC. In addition, there are national policies of member countries which further distort farm output and input prices<sup>3</sup>. The exact extent of these distortions is difficult to measure, however, given the wide range of qualities to which product prices refer, the presence of marketing margins and intra-EC transportation costs, and the fact that much of the international food trade of EC member countries is with other member countries so that unit values of that trade do not provide an indication of EC border prices. Nonetheless, an indication of the nominal rate of EC border protection (excluding additional national protection) is provided by the Eurostat data summarized in Table 1. Those data show the percentage by which the import price at the port of entry is raised by the system of variable import levies. Four-year averages are shown to eliminate the considerable year-to-year fluctuations<sup>4</sup>.

Clearly, rates of protection are very high. EC producer prices rose steadily in nominal terms throughout the period shown, while international prices fell in the latter 1960s, rose over the mid 1970s and fell again in the latter 1970s. The weighted average nominal rate of protection for the products shown was 118 per cent for the 4 years around 1970, and by the end of the 1970s it was 154 per cent. (The average rate of protection dropped in the mid-1970s because international prices rose to unprecedented levels, but it still averaged 59 per cent and was close to zero only for rice, oilseeds and sugar.) Protection rates have been highest for dairy products and sugar, but grain and meat rates are also very high.

There has been an upward trend in agricultural protection for some time both in the EC and in other western European countries. Available estimates suggest that the average nominal rate for all of western Europe rose from 38 per cent in 1956/57 to 47 per cent in 1963/64, 62 per cent in 1968/69 and 80 per cent in the early 1970s<sup>5</sup>.

The steady rise in domestic food prices has stimulated growth in output, dampened consumption growth and thereby reduced net import demand considerably. As a result, self-sufficiency ratios have risen for virtually every farm product shown in Table 1, and are now above 100 per cent for all but corn, rice and oilseeds. Hence the concern of traditional food exporters that if recent trends continue, the EC will become a major competitor in third country markets.

The system of variable import levies not only raises the level of grain and meat prices in the EC but also reduces the instability of those prices. The coefficients of variation of domestic prices have been only a small fraction of those for international prices of grain and meat.

#### **MODELLING THE EFFECTS OF EC GRAIN AND MEAT POLICIES**

To estimate the effects of EC grain and meat price and trade policies on the level and instability of international prices in the interdependent markets for these products, a model is needed which has at least the following features:

- . it should be global in coverage so that international terms of trade effects are endogenous,
- . it should incorporate both the protectionist and domestic-market-insulating components of commodity trade policy,
- . it should incorporate the cross effects in both demand and supply between interdependent commodity markets, and
- . both domestic and international supply uncertainty should be included so that the effect of market-insulating policies on price instability is determined endogenously.

In this paper we use a simulation model with these features. It is a revised version of a model first described by Tyers and Chisholm. It simulates the international markets for five commodity groups: wheat, coarse grain, rice, the meat of ruminants (cattle and sheep) and the meat of non-ruminants (pigs and poultry). In it the world is disaggregated into 24 countries and country groups, 6 of which are modelled as net trading entities only. The Appendix provides a mathematical description of the model and a summary of the EC parameters used, further details of which appear in Tyers.

Consumption behaviour in each country is assumed to be characterised by constant income and price elasticities of demand. Production behaviour is represented by a "partial adjustment" model which is linear in the logs of production and producer prices (Nerlove). Production in each country and country group is disturbed randomly in each simulation and the means and variances of key variables calculated from 100 repetitions. Each simulation begins with the year 1981 and ends in 1990 and hence each constitutes a projection based on a particular series of random disturbances (a particular intertemporal weather pattern).

Policies affecting trade are incorporated in the model through the specification of a price transmission equation for each country and commodity. This equation captures both the protection and the market insulation components of price and trade policies. The two components are difficult to separate because market insulation requires that, when the world price of a commodity changes, the nominal rate of protection should also change, at least in the short run. In the present version of the model it is assumed that governments aim to retain a constant average level of protection in the long run. That is, price transmission elasticities are less than unity in the short run but are assumed to equal one in the long run and to approach that long-run value according to a Nerlovian partial-adjustment type of lag distribution (equation (8) in the Appendix). The smaller the short-run transmission elasticity, the greater the degree of market insulation and the more sluggish is the eventual transmission of any sustained change in the world price. The short-run transmission elasticities for each country and commodity are based on econometric analysis of time series data on domestic and border prices for the late 1960s and 1970s<sup>6</sup>.

The welfare effects of a policy change, as generated by the model, have a number of components. The benefit to consumers is the expected Equivalent Variation, the benefit to producers is the expected change in producer surplus, the government revenue effect pertains to the net budgetary effect of producer, consumer and trade taxes and subsidies, and a storage benefit is included which is based on profits from the holding of stocks<sup>7</sup>.

## **THE RESULTS**

In this section, three sets of results are presented. The first shows the effects of EC grain and meat policies on the level and instability of world prices and on international trade in these products as of 1980. The second projects the effects through the 1980s of continuing to maintain real grain and meat prices in the EC at their 1980 level, and compares this scenario with two others which (i) EC domestic prices grow at 2 percentage points less than the rate of inflation, and (ii) EC wheat producers are charged a 2 per cent levy to help cover the cost of export subsidies. The third set of results shows what the effects would be if the United States introduced a wheat export subsidy to try to retain its share of the world market in the face of rising EC exports.

### **Effects of Complete Liberalization**

To estimate the effects that EC policies have had on grain and meat prices and trade, the model compares the actual market situation in 1980 (the reference case) with the

estimated situation in the absence of EC protection and market insulation (after the necessary supply adjustments - the complete liberalization case).

The results are shown in Table 2. The first point to note is that international prices for wheat, coarse grain and ruminant meat would be about 13 to 17 per cent higher if the EC were to completely liberalize its trade in grain and meat products. Because of those international price rises, domestic EC prices would fall by somewhat less than is implied by the apparent nominal rates of protection shown in Table 1<sup>8</sup>. Wheat, coarse grain and ruminant meat prices in the EC would fall by about 40 per cent, non-ruminant meat prices would fall about 25 per cent and rice prices 20 per cent.

Secondly, the instability of international prices is considerably reduced following EC liberalization. This is shown in Table 2 as a drop in the coefficient of variation of those prices. For wheat this coefficient is halved while for the coarse grain and ruminant meat it drops about one third.

Thirdly, the volume of net EC imports increases enormously under free trade. The EC switches from being a net exporter to the rest of the world of more than 6 million metric tons of wheat annually to importing around 8 million metric tons. Coarse grain imports increase from 5 to 31 million metric tons, ruminant meat imports increase by 3 million tons, and non-ruminant meat exports rise by 2 million tons.

World trade changes are somewhat smaller than EC trade changes, because of the effects of international price changes on export supplies and import demands elsewhere in the world. Nonetheless, they are still very substantial. International trade volumes are 14 per cent greater for wheat and 22 per cent greater for coarse grain, amounting to a total increase in grain trade of 35 million metric tons. World meat trade expands by about two thirds, or 4.7 million tons.

The United States is the country with by far the most to gain from EC liberalization. Its grain exports would expand by 25 million metric tons, compared with expansions of 3 million tons each for Australia and Canada. Australia and New Zealand would also expand their ruminant meat exports substantially (in percentage terms). The price changes also cause Japan, the USSR and India to import less grain and meat<sup>9</sup>.

The magnitude of these price and trade effects is underlined when they are compared with those due to Japan's protection and those due to all developed market economies' (DME's) protection. Table 3 suggests that Japan has an important effect on the world rice and beef market, but overall the EC's policies have had much more impact on

**Table 2: Price and Trade Effects of Complete Liberalization of Grain  
and Meat Markets in the EC <sup>a</sup>**  
(million metric tons and per cent)

	Wheat	Coarse Grain	Rice	Ruminant Meat	Non-ruminant Meat
<b>International Prices</b>					
Per cent change in mean	13	16	5	17	1
Coefficient of variation					
- reference	.51	.21	.33	.08	.08
- liberalization	.25	.14	.29	.06	.08
<b>EC Domestic Prices</b>					
Per cent change in mean	-43	-40	-20	-39	-27
<b>EC Net Imports</b>					
Change in volume	14.7	26.0	-2	3.0	-2.0
<b>World Trade</b>					
Change in volume	12.3	23.2	0	2.7	2.0
Per cent change	14	22	0	65	68
<b>Selected Countries' Net Exports <sup>b</sup></b>					
Change in volume					
Australia	2.5	.3	-0	.3	.0
Canada	1.7	1.5	-0	.0	-1
New Zealand	.0	.0	.0	.1	-0
United States	4.8	20.2	-1	1.8	-1.4
Japan	-3	1.4	.0	.1	.3
USSR	.5	.3	.0	.0	-0
India	3.4	.8	-9	.0	-0

d These results are derived from a comparison of a reference case, based on 100 simulations assuming no growth in population or income in any country, with a corresponding liberalization case in which all EC grain and meat trade barriers are removed. The results therefore approximate the asymptotic market changes which could be expected on full supply adjustment were this to be achieved instantaneously as of 1980. See the discussion in the text.

b For importing countries, such as Japan and the USSR, a positive change in "net export" volume means a decrease in imports.

**Table 3: International Price and Trade Effects of Agricultural Protection  
in the EC, Japan and All Developed Market Economies (DMEs)<sup>a</sup>**

	Wheat	Coarse Grain	Rice	Ruminant Meat	Non-ruminant Meat
<b>International Price Level</b>					
Per cent change following:					
EC liberalization	13	16	5	17	1
Japan liberalization	0	1	7	8	1
All DME liberalization	20	16	14	24	2
<b>International Price Instability</b>					
Coefficient of variation before lib.	.51	.21	.33	.08	.08
Coefficient of variation after:					
EC liberalization	.25	.14	.29	.06	.08
Japan liberalization	.44	.21	.31	.07	.08
All DME liberalization	.23	.14	.26	.05	.08
<b>World Trade Volume (million metric tons)</b>					
Increase following:					
EC liberalization	12.3	23.2	.3	2.7	2.0
Japan liberalization	.5	-.2	4.7	2.0	.4
All DME liberalization	7.5	24.4	4.0	3.9	1.9

<sup>a</sup> These results are derived from comparisons between a reference case, based on 100 simulations assuming no growth in production, population or income in any country, with three corresponding liberalization cases in which (1) all EC grain and meat trade barriers are removed, (2) all Japan's grain and meat trade barriers are removed, and (3) all developed market economies' grain and meat trade barriers are removed. The results therefore approximate the asymptotic market changes which could be expected on full supply adjustment were this to be achieved instantaneously as of 1980. See the discussion in the text.

international grain and meat markets than have Japan's policies. Indeed, except for rice, the EC's policies have had more international impact than the combined effects of all other DME's policies. Virtually all of the instability in international prices for wheat and coarse grain induced by DME policies is attributable to the EC, as is at least two thirds of the international price-depressing effects of DME policies.

The national per capita welfare effects of the EC's policies are calculated using equation (35) in the Appendix <sup>10</sup>. In addition to the EC itself, the food-exporting countries of Australasia and North America (and Argentina, not shown) are the main losers from EC protection. Their per capita losses, measured in 1980 US dollar terms, amount to \$95 for the EC, \$85 for New Zealand, \$35 for Australia and \$10 for Canada and for the United States. Japan, however, benefits from EC protection to the extent of \$35 per capita, because it is a net importer of grain and meat. For the same reason the USSR, and the developing countries as a group, benefit slightly (\$2 per capita for the USSR, less than \$1 for developing countries).

#### **Effects of Less Extreme Changes in EC Policies**

Complete liberalization of EC agricultural protection is of course not a realistic policy scenario for the 1980s. Not only are domestic producers likely to remain protected from import competition, but also they are likely to continue to be insulated from year-to-year fluctuations in international prices.

In recent years, annual farm price rises in the EC have been set at close to the rate of inflation (Langworthy, Pearson and Josling). Whether that policy will continue through the 1980s depends on the extent of surplus grain and meat generated, on international prices (which determine the amount of export subsidy required to dispose of that surplus), and on whether national governments vote to increase their contributions to the EC budget to finance export subsidies. If real prices are maintained in the EC and do not rise internationally, it is likely that export surpluses and the budgetary cost involved in their disposal on world markets will increase. This likelihood may be sufficient to convince the EC Council of Ministers that farm prices should not continue to increase as rapidly as inflation, or that producers should bear some of the cost of export subsidies.

To examine the importance of future price policy decisions for world grain and meat markets, two scenarios are compared with a reference scenario in which it is assumed that, through the decade of the 1980s, grain and meat prices in the EC are maintained at their 1980 level in real terms.

(i) Real EC grain and meat prices fall 2 per cent per year

The first alternative scenario assumes EC grain and meat prices fall 2 per cent each year in real terms. If inflation in the EC averages 8 per cent during the 1980s, this assumption would imply that these prices rise at only three quarters the rate of inflation. The results reported in Tables 4 and 5 show the differences between this scenario and the reference scenario in which real prices remain constant <sup>11</sup>.

A surprising feature of these results is that even a small decline in real agricultural prices in the EC, rather than a continuation of the policy of maintaining real domestic price levels, can have a marked effect internationally. If EC domestic grain and meat prices were to rise at 2 percentage points less than the rate of EC inflation, international prices in 1990 would be up to 7 per cent higher than if real domestic farm prices remain unchanged through the 1980s. EC wheat and meat export volumes would be 3.4 and 1.5 million tons lower, respectively, and EC coarse grain imports would be almost 10 million tons greater. Annual world trade in grain would be 8 million tons greater in 1990, when world meat trade would be .3 million tons greater. Australasia and North America as a group would supply most of this increase (Table 4).

The projected effects of these scenarios on EC rates of protection, production, net imports and self sufficiency are shown in Table 5. In the case in which real EC prices are maintained (the "0% case" in the table), protection rates in the EC would change little. This reflects the fact that the model projects very little change in international prices for grain and meat through the 1980s if policies remain unchanged globally. In the case in which real prices fall 2 per cent annually, protection rates roughly halve for wheat, coarse grain and ruminant meat and fall to low levels for rice and non-ruminant meat.

Even in the partial liberalization case, production in the late 1980s is projected to exceed that in the late 1970s, due to the assumption that there will be some exogenous (from the point of view of the model) productivity growth.<sup>12</sup> Consumption continues to grow, however, and more so in the partial liberalization case.

The net effects on self sufficiency are shown in the final columns of Table 5. Self sufficiency in wheat, coarse grain and ruminant meat increases substantially through the 1980s if EC domestic prices continue to rise at the rate of inflation, while rice and non-ruminant meat decline slightly. The EC would become almost completely self sufficient in coarse grain by 1990, and would be exporting more than 20 per cent of its wheat production and 5 per cent of its ruminant meat production. On the other hand, if EC prices were to grow at 2 percentage points less than the rate of inflation, self sufficiency

**Table 4: International Price and Trade Effects of an Annual 2% Fall as Compared  
with No Change in Real Domestic Grain and Meat Prices in the EC  
During the 1980s<sup>a</sup>**

		Wheat	Coarse Grain	Rice	Ruminant Meat	Non-ruminant Meat
<b>International Prices</b>						
Per cent change in mean	1985	4	4	1	4	3
	1990	7	6	2	6	4
<b>International Trade (kt)</b>						
Change in EC net exports	1985	-1,070	-4,200	25	-414	-374
	1990	-3,450	-10,768	39	-823	-630
Change in world trade	1985	-313	3,723	-104	67	104
	1990	-1,456	9,642	-325	146	169
Change in 1990 net exports from:						
Australia		639	170	-4	71	9
Canada		378	800	-1	-6	29
New Zealand		-5	16	0	31	-3
United States		930	7,805	-22	481	-334
Japan		-149	490	-26	19	59
USSR		208	123	5	13	2
India		680	709	-199	0	6

<sup>a</sup> These results are derived from comparing a reference case, in which EC real domestic prices for grain and meat remain unchanged through the 1980s, with a partial liberalization case in which EC real domestic prices for grain and meat are reduced by 2 per cent per year from 1981 to 1990.

**Table 5: Projected Effects of an Annual 2% Fall and of No Change in Real EC Domestic Grain and Meat Prices on EC Protection Rates, Production, Net Imports and Self Sufficiency During the 1980s <sup>a</sup>**  
(million metric tons pa and per cent)

	Nominal Rate of Protection (%)			Production			Net Imports			Self Sufficiency (%)		
	1990		1978-80 actual	1988-90		1978-80 actual	1988-90		1978-80 actual	1988-90		
	0% case	-2% case		0% case	-2% case		0% case	-2% case				
Wheat	110	133	79	48.7	56.9	53.9	-4.2	-12.3	-9.3	110	128	121
Coarse grain	83	80	38	67.9	78.1	72.3	6.8	2.8	12.2	91	97	86
Rice	47	33	7	.6	.7	.6	.3	.4	.4	66	63	64
Ruminant meat	94	88	49	7.3	8.4	8.2	.1	-.4	.3	99	106	99
Non-ruminant meat	30	38	12	13.0	14.4	14.9	-2	.1	.6	102	100	96

<sup>a</sup> As with Table 4, the two cases shown for 1988-90 refer to those discussed in the text: the first assumes no change in real EC domestic prices for grain and meat over the 1980s, the second assumes these prices fall by 2 per cent per year in real terms through the 1980s.

**Table 6: Projected Effects on National Economic Welfare in 1990  
of an Annual 2% Fall as Compared with No Change in Real Domestic Grain  
and Meat Prices in the EC <sup>a</sup>**  
(1980 \$US billion)

	Effects <sup>b</sup> on:			Total <sup>c</sup>
	Consumer Welfare	Producer Welfare	Government Revenue	
<b>Developed Market Economies</b>				
EC	20.3	-13.2	4.4	11.5 (43)
Australia	-.4	.8	.0	.4 (22)
New Zealand	-.1	.2	.0	.1 (41)
Canada	-.4	.5	-.0	.0 (2)
Japan	-1.5	-.6	-.2	-2.2 (-18)
United States	-3.6	4.0	-.1	.2 (1)
<b>Developing Market Economies</b>				
Northeast Asia	-1.8	-.6	-.3	-2.6 (-13)
Southeast Asia	-.5	.4	.0	-.2 (-1)
South Asia	-1.2	1.0	-.0	-.2 (-0)
Africa	na	na	na	-.4 (-1)
Latin America	na	na	na	-.3 (-1)

- a As with Table 4, these results are derived from comparing a reference case, in which EC real domestic prices for grain and meat remain unchanged through the 1980s, with a partial liberalization case in which EC real domestic prices for grain and meat are reduced by 2 per cent per year from 1981 to 1990.
- b The consumer welfare benefit is the expected Equivalent Variation. The producer welfare benefit is the expected gain in producer surplus. For details of these formulations, see Appendix Table A2.
- c Numbers in parentheses are net economic benefits per capita, in 1980 US dollars.

levels in the late 1980s would be slightly below those of the late 1970s except in the case of wheat.

The differences between the welfare effects of these two alternative EC policy scenarios for the 1980s are summarized in Table 6 for the year 1990. Clearly, EC consumers would gain in the more liberal case whereas, because of the higher international prices, consumers elsewhere would be worse off in this case. The opposite result emerges for producer welfare: EC farmers are worse off in the partial liberalization case but grain and meat producers in the rest of the world other than Japan<sup>and Korea</sup> are better off. (In Japan<sup>and Korea</sup>, the gain to producers from increased output prices is insufficient to offset the loss to livestock producers from increased feedgrain prices.) The EC budgetary outlays are \$7.4 billion less in the partial liberalization case as compared with the real price maintenance case because of the reduced export subsidy bill in the former scenario.

The huge transfers between EC consumers/taxpayers and EC producers is more extreme than appears in Table 6 when put on a per capita basis. If the more rather than the less protectionist of the two policies were to be adopted, per capita net incomes of EC farmers would be \$800 (in 1980 terms) higher while EC consumers-cum-taxpayers would be only \$100 or less than 1 per cent worse off. This difference helps explain why it is more in the interests of farmers to seek protection than it is in the interests of consumers to oppose it.

The final column of Table 6 shows the net economic welfare effects in total and per capita terms. The net gain to the EC from adopting the less protectionist of these two scenarios is a very considerable \$12 billion, or \$43 per capita. As with complete liberalization, it is North America and Australasia which gain most if a less protectionist policy is adopted, while food-deficit Japan and the developing country bloc would lose. Developed market economies as a whole would be better off in 1990 to the extent of \$10 billion (in 1980 terms), whereas developing market economies would be worse off by \$3.7 billion.

(ii) A 2% levy applied to EC wheat producers

Perhaps the most critical restraint on increases in EC food prices is the budgetary cost of disposing of surpluses. Among the five commodity groups under consideration here, wheat is by far the most costly to the EC budget. The Commission of the EC is considering the idea of applying a levy on wheat producers so that they pay a portion of the cost of disposing of surpluses internationally. Leaving aside the difficult question of how such a levy could be collected, this section examines the effects such a move could have on the international wheat market.

Suppose that all EC wheat production is taxed at a rate of, say, 2 per cent of the domestic price. This would not affect domestic consumption but would lead to a reduction in production and hence in exports. The international wheat price would rise slightly as a result of reduced EC exports, and both changes would reduce EC export subsidy payments, part of which could now be funded from producer levy receipts. Such a policy change would clearly benefit other wheat exporters in addition to the EC.

However, the EC Commission is evidently more concerned with raising farm prices than with improving the efficiency of resource use or with the welfare of EC consumers or of producers in non-EC countries. It is quite likely, therefore, that the domestic wheat price would be raised at the same time as a levy is applied, just as has happened with the domestic price of sugar following the introduction of a levy on EC sugar producers. Conceivably the domestic price could rise to the point where, before all the producer levy revenue is spent on extra export subsidy payments, exports would be even greater than if there were no levy and no change in the real domestic price. Table 7 demonstrates that such an increase in domestic prices and exports is indeed a possibility.

The first set of columns in Table 7 shows the effects of imposing from 1984 a levy of 2 per cent of the domestic price on wheat producers while leaving the consumer price for wheat unchanged. EC wheat exports would drop by .7 million tons by 1985 and 1.0 million tons by 1990. As a result the international price would rise 1 per cent and the drain on the EC budget would be reduced by \$600-700 million (in 1980 terms). Exports from the other major wheat-surplus countries would expand, so that by 1990 the EC's share of the international wheat market would be 1.1 percentage points less while the shares for the United States, Canada and Australia would be 1.0, .4 and .3 percentage points greater than in the absence of the levy.

However, if the EC Commission is concerned only with not increasing its budgetary outlays before 1990, it could raise the real consumer price as much as 4 per cent while applying the 2 per cent producer levy (so that the real wheat price received by EC farmers rises almost 2 per cent). The effects of this policy are shown in the middle set of columns of Table 7. In this case EC wheat exports would expand by more than 1 million tons above what they would have been with constant (1980) real prices in the EC, and self sufficiency would be 4 percentage points higher at 132 per cent by the end of the decade. The international wheat price would drop 1 per cent, and other wheat exporters would reduce their exports. By 1990 the EC share of the international wheat market would be 2 percentage points more than if domestic EC prices had remained unchanged,

**Table 7: Projected Effects on the World Wheat Market  
of a 2% Levy on EC Wheat Production**

	Assumed Change (from the 1980 Level) in the Real EC Consumer Price of Wheat <sup>a</sup>					
	0%		4%		6%	
	1985	1990	1985	1990	1985	1990
Change in EC budget cost (1980 \$billion)	.6	.7	.2	.0	.0	-.3
Change in international wheat price (%)	1.0	.9	-1.2	-1.2	-2.2	-2.3
Change in world trade volume (kt)	-102	-335	165	580	306	1,047
Change in net exports (kt) from:						
EC	-705	-999	1,148	1,685	2,061	3,016
United States	373	395	-559	-754	-1,074	-1,325
Canada	73	88	-121	-167	-217	-296
Australia	74	111	-125	-203	-223	-361
Change in world trade shares (percentage points):						
EC	-1.0	-1.1	1.6	2.0	2.9	3.5
United States	.4	1.0	-1.0	-1.2	-1.7	-2.2
Canada	.1	.4	-.2	-1.5	-.4	-.6
Australia	.1	.3	-.2	-.4	-.4	-.5

<sup>a</sup> All other EC agricultural prices are assumed to be unchanged from their 1980 level, as are agricultural policies in all other countries.

**Table 8: Projected Effects on World Grain Markets of US Retaliation,  
via a 15% Wheat Export Subsidy, Against EC Export Subsidies <sup>a</sup>**

	Wheat		Coarse Grain	
	1985	1990	1985	1990
<b>International Prices</b>				
Percent change in mean	-8.3	-7.8	-4	.3
<b>International Trade</b>				
Change in world trade volume (kt)	1,042	3,024	-12	-149
Change in world trade volume (%)	1.5	3.8	-0	-2
Change in net exports (kt) of:				
United States	2,804	4,447	-1,508	-1,466
EC	-3	-9	-19	-52
Canada	-654	-687	320	482
Australia	-655	-818	194	284
Change in net export value (%) of:				
United States	-1	3	-3	-2
EC	8	-8	-1	-2
Canada	-13	-12	4	5
Australia	-15	-14	3	4
Change in world trade shares (percentage points):				
United States	3.1	4.1	-1.7	-1.5
EC	-2	-6	.0	0
Canada	-1.3	-2.4	.4	.5
Australia	-1.2	-2.5	.3	.3

- <sup>a</sup> These results are derived from comparing a reference case, in which all countries protection-cum-stabilization policies remain unchanged, with a case in which the United States adds a 15 per cent subsidy on its wheat exports during each year from 1983.

and the United States, Canadian and Australian shares would be 1.2, 2.0 and .4 percentage points less.

If the EC is concerned only with not increasing its budgetary outlay in the short term (1985), it could raise domestic wheat prices to consumers as much as 6 per cent (producer prices by almost 4 per cent), as shown in the final set of columns in Table 7. The effects in this case, are of course commensurately larger.

Clearly, a system of producer levies to ease the EC budgetary problem need not necessarily reduce the problem for other food exporters facing increasing competition from EC exports. On the contrary, levies may strengthen that competition, to the detriment of wheat producers in the rest of the world.

### **Effects of a US Wheat Export Subsidy**

In the past, the exporting countries most adversely affected by the EC's grain and meat policies have had almost no success in persuading the EC to restrain its assistance to agriculture. Out of exasperation, the United States has threatened to retaliate by subsidizing its own agricultural exports. Dairy products and wheat are the main export items that were subsidized for this reason in 1983 (either directly or indirectly via blended credit programs).

The effects of imposing a 15 per cent subsidy on US wheat exports from 1983 are summarized in Table 8, assuming no change in other countries' policies through the 1980s. Such a subsidy would reduce the international wheat price by 8 per cent and cause the volume of wheat traded internationally to be almost 4 per cent greater by 1990 than in the absence of the US subsidy. US exports of wheat would be 3 to 4 million tons greater, but its coarse grain exports would be 1.5 million tons less, mainly due to substitution in domestic production. EC net exports would change very little because the EC markets are almost entirely insulated from world price changes. Wheat exports from Canada and Australia would drop considerably, and would be only partly offset by increased exports of coarse grain.

The drop in the international wheat price and in US coarse grain exports would mean that

US grain export receipts would not increase even though its wheat export volume would expand by up to 10 per cent. The EC of course would lose foreign exchange because of the international wheat price decline but, in percentage terms, Canada and Australia would lose just as much because of their reduced export volumes.

While a 15 per cent wheat export subsidy would raise the US share of the international wheat market by 3 to 4 percentage points above what it would be in the absence of the subsidy, this would not restore the US share to its early 1980's level. Indeed, a wheat export subsidy of more than 25 per cent would be necessary to ensure that the US share of the early 1980s was maintained through the rest of the decade. But then the US share of the international market for coarse grain would have fallen 4 percentage points. The bottom rows of Table 8 show that the gain in the US share of the world wheat market would be at the expense not so much of the EC but of Canada and Australia.

The major aim of a subsidy on US wheat exports would be to raise the budgetary cost of the EC export subsidy program beyond its present limit. According to these results, however, the budgetary cost would be much greater for the US than for the EC. The annual cost to the US treasury would be between \$.8 billion and \$1.0 billion, whereas it would add only an extra \$130 to \$200 million annually to the EC budget. There are two main reasons for the difference. First, the US price subsidy is 15 per cent per unit of exports, but the terms of trade effect imposes only an extra 8 per cent subsidy cost per unit of EC exports. Second, the volume of wheat exported from the US and therefore attracting the subsidy is five times the EC volume. The relatively small impact on the EC budget is likely to be insufficient to force any significant change in the CAP. Even if the impact were to be made larger, for example by also subsidizing US exports of dairy products, the most likely response would be the approval by member governments to increase the EC budget. This could be achieved in the context of discussions already underway on additional funds for EC enlargement to include Spain and Portugal.

In short, a 15 per cent subsidy on US wheat exports would be unlikely to have much impact on the EC and would be extremely expensive not only for the US but for other wheat exporters, particularly Canada and Australia. In 1985, the net economic welfare loss would be \$1000 million for the United States, \$170 million for Canada, \$100 million for Australia, and \$130 million for the EC (in 1980 terms). In per capita terms, therefore, the US, Canada and Australia are hurt much more than the EC (\$4 to \$7 for the former group compared with 50 cents for the EC). While developing market economies and centrally planned economies, as net importers of wheat, would gain from a US wheat subsidy, their gain would be insufficient to offset the losses suffered by the wheat-exporting nations. That is, the scheme is not even a very efficient way to transfer spending power from food-exporting developed countries to food-deficit developing countries, particularly since one quarter or more of the gain by food importers accrues to centrally planned economies.

### **Qualifications to the Results**

The above results, it should be remembered, refer only to grain and meat. If dairy products and sugar had also been included, the costs of continued protection in the EC would be substantially higher for the EC and for Australasia. In addition, because of the importance of sugar exports to a number of developing countries, the developing country bloc may be net losers rather than gainers from EC agricultural protection.

Soybean and other feedgrain substitutes (manioc, corn gluten, citrus pellets), which enter the EC at low or zero tariffs, are not included in this model either. If the EC's coarse grain import barriers were to be reduced substantially, it is likely that imports of these feedgrain substitutes would be reduced. Indeed the EC has indicated that it may raise barriers to imports of grain substitutes if it decides to lower grain import barriers. (A "voluntary" export restraint was in fact introduced in 1982 to inhibit manioc imports from Thailand.) Whether the prices of grain substitutes on international markets would rise or fall depends on the extent to which their reduced demand in the EC is offset by the flow-on effect of the increase in international prices for coarse grain following EC liberalization. The United States would be the country affected most adversely by any reduced demand for grain substitutes, but this would probably represent only a small offset to the benefit from increased grain exports.

## SUMMARY AND CONCLUSIONS

Four sets of results emerge from this analysis. First, while EC grain and meat policies raise the level and reduce the instability of prices within the EC, they also have the following important international effects as of 1980:

- . they depress international prices for wheat, coarse grain and ruminant meat by about 15 per cent;
- . they increase the instability of international prices (as measured by the coefficient of variation) by about 30 per cent for ruminant meat, by 50 per cent for coarse grain and by 100 per cent for wheat;
- . they reduce world trade in grain and meat by about one fifth and two thirds, respectively;
- . in these three respects they are much more important than the policies of all other developed market economies combined; and
- . they reduce welfare substantially not only in the EC but also in the major grain- and meat-exporting countries of Australasia, North America (and Argentina) while benefitting somewhat the food-deficit countries including (marginally) developing countries as a group.

Second, if the EC were to embark on even a slight degree of sustained reductions in domestic food prices, the gains to the EC and to other food exporters could be considerable by 1990. In the case examined, in which EC domestic real prices for grain and meat are reduced 2 per cent per year rather than kept constant over the 1980s, the international effects in 1990 are as follows:

- . international grain and meat prices are up to 7 per cent higher;
- . EC exports of wheat and meat are 3.4 and 1.5 million tons lower, respectively, while coarse grain imports are <sup>of meat</sup> 10 million tons greater, ensuring that self sufficiency ratios are no higher than in the late 1970s; and
- . Australasia and North America export 11 million tons more grain.

Third, if instead the EC introduced a 2 per cent levy on wheat production to reduce the EC budgetary outlay on export subsidies, economic efficiency would be improved only if EC consumer prices were not raised at the same time. But since the levy revenue eases the budget problem which is the main political constraint on domestic prices, it is quite likely that the real domestic wheat price would rise if a producer levy were to be introduced. It could rise as much as 4 per cent (for consumers, 2 per cent net for producers) and even by 1990 wheat export subsidies would not require any additional funds from the EC budget net of levy receipts. The international effects in 1990 of such a policy as compared with no change in domestic prices are as follows:

- EC wheat exports are 1 million tons greater and EC wheat self sufficiency is 4 percentage points higher at 132 per cent;
- the international wheat price is 1 per cent higher; and
- the EC share of the international wheat market is 2 percentage points more while the United States, Canadian and Australian shares are 1.2, 2.0 and .4 percentage points less.

Fourth, should the United States choose to retaliate against EC export subsidies by imposing a 15 per cent subsidy on US wheat exports, other countries as well as the EC and the US would be adversely affected. Assuming EC policies do not change in response to a US retaliatory subsidy, as seems likely, the following international effects would result:

- the international wheat price falls 8 per cent;
- US wheat exports are 3 or 4 million tons greater (but US coarse grain exports are 1.5 million tons less), EC grain trade is virtually unchanged, and Canadian and Australian grain exports drop considerably;
- the US share of the international wheat market rises 3 to 4 percentage points, but this is only half what is needed to raise its share to the level of the early 1980s, and it is almost entirely at the expense of Canada and Australia;
- the US Treasury outlay is close to \$1 billion (in 1980 terms) annually but the EC budget cost of additional wheat export subsidies is less than \$200 million which is unlikely to be sufficient to alter CAP policies; and

- the per capita economic loss to the United States, Canada and Australia is many times greater than the loss to the EC.

Despite the large cost of the CAP to the EC and to other food exporters, advocates for reform have been remarkably unsuccessful in persuading the EC to restrain its assistance to agriculture. Even so, such efforts should not be abandoned, tempting though that option may seem to exasperated negotiators. This is because the adverse effects of EC policies are likely not only to continue but to intensify. Moreover, the more western European agricultural protection is seen by other food importers as being acceptable to the international community, the more likely they too will succumb to domestic political pressures to protect their agricultural sectors. Japan has already done that, and a number of newly industrializing countries seem to be following the same example (Anderson, Tyers and Anderson). Given that political pressures are likely to favour agricultural protection increasingly as economies industrialize and their farm sectors decline, particularly in food-deficit countries which can assist agriculture with import controls rather than with budgetary outlays, the main hope for containing the growth of agricultural protectionism lies with the international pressure which food-exporting countries can bring to bear. Hopefully empirical analyses such as the present study can help to make those efforts more effective.

## FOOTNOTES

1. See, for example, Buckwell, Harvey, Thompson and Parton, Josling and Pearson, and the references cited therein.
2. The importance of the effects of protection-cum-stabilization policies on the level and instability of international food prices has been stressed by Johnson. See also Bale and Lutz. Most of the empirical literature which examines both mean and variance effects relates to wheat. See Sarris and Freebairn and the references cited by them. Valdes and Zietz consider a large number of commodities, but pay little attention to interactions between the markets for these commodities and do not address the instability issue.
3. Dicke and Rodemer suggest that input subsidies add the equivalent of a further 10 percentage points to the nominal rate of EC agricultural protection.
4. The grain protection estimates in Table 1 are close to those obtained in other studies. See, for example, Jabara and Brigida, and Koester.
5. See Gulbrandsen and Lindbeck, and UNCTAD (p.73).
6. The price transmission elasticity concept was popularised for policy analysis by Bredahl et al. Tyers presents estimates of the elasticities of price transmission for all the countries included in the present grain/meat model. Note that if the short run elasticity is zero, then so too is the long run elasticity in this model.
7. These welfare measures are presented mathematically in Table A2 of the Appendix. The incorporation of grain storage behaviour is based on an empirical adaptation of a model for risk-neutral competitive speculators (Aiyagari et al.). The adaptation incorporates a term in quantities only, to explain stock changes in countries where government-held stocks dominate and where closing stocks do not depend significantly on either insulated domestic prices or international prices. The econometrically-based storage parameters are held constant throughout the experiments discussed in this paper. Consequently, in the results presented, changes in stocks do not significantly affect the policy impacts examined nor are changes in profits from stock-holding a significant component of the aggregate welfare change estimates.

8. After correcting for the terms of trade effect, the estimates of the nominal rates of protection in 1980 change as follows:

	Wheat	Coarse grain	Rice	Ruminant meat	Non-ruminant meat
Apparent rate of protection (%)	110	83	47	94	40
Corrected rate of protection (%)	86	58	40	66	39

9. Even though India is only a marginal grain trader, the rise in the price of wheat relative to rice would lead it to arbitrage a small percentage of its rice for wheat. But because it is such a large producer and consumer of grain, this translates to a considerable change in its international trade in these products.
10. Partial equilibrium analysis can only provide a reasonable indication of welfare effects of agricultural policy if effective assistance to other tradable sectors is close to zero. (If, for example, other sectors enjoyed greater assistance than agriculture, liberalizing agricultural trade would induce resource transfers to more-assisted sectors and thereby worsen the efficiency of resource use.) As it happens, the other main tradable sector in the EC, manufacturing, receives relatively low rates of assistance. Effective rates of assistance via tariff protection for the manufacturing sector are estimated to have averaged less than 10 per cent in the latter 1970s (Cline et al.). While non-tariff barriers would have raised the rate of overall assistance to manufacturing somewhat, the sectoral average for manufacturing would still be very low compared with that for agriculture implied by the estimates shown in footnote 8.
11. The model projects international food market behaviour to 1990 based on assumed growth trends in the national incomes and populations of each country and country group. The population growth assumptions accord with those of the World Bank's World Development Report of 1981. National income projections are based on short run forecasts published in various issues of the OECD Observer and judgemental forecasts for the latter 1980s. The long run behaviour of the model is also dependent on estimates of the non-price-dependent component of production growth, principally that due to cost-reducing technological change. Projections of the latter are based on extrapolations of past trends estimated econometrically in the course of estimating the supply response parameters, but adjusted downwards for the EC. Further details are available in Table A3 and in Tyers.

12. *The assumed annual rates of exogenous growth in EC production for the 1980s are .5% of rice, 1.5% for wheat, coarse grain and ruminant meat, and 2.0% for non-ruminant meat. These are considerably below the growth rate of the 1970s.*

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## APPENDIX

The model disaggregates the world into 24 countries or country groups, of which 18 have econometrically-based behavioural equations for production, consumption and stocks and 6 are represented only as net trading entities. The former group includes Australia, Bangladesh, Burma, Canada, EC-9, India, Indonesia, Japan, Malaysia, New Zealand, Pakistan, the Philippines, Singapore, South Korea, Sri Lanka, Taiwan, Thailand, and the United States. The net trading entities are Latin America, Africa, China, the USSR, the Middle East and other Asia, and other Europe.

For each of the five commodity groups (wheat, coarse grain, <sup>rice,</sup> ruminant meat and non-ruminant meat), each of the first set of countries' consumption, production, stocks, trade and price transmission behaviour are modelled as shown in equations (1) to (13) in Table A1, and their consumer benefit, producer benefit, government revenue and net economic welfare effects are calculated from equations (14) to (37) in Table A2. Table A3 lists the major parameters for the EC that enter the model. Parameters for other countries are listed in Tyers.

The model is solved iteratively by beginning each new year with the assumption that all prices are the same as those in the preceding year, generating random disturbances in production and net trade, as well as calculating the production, consumption and closing stock levels in each country. The resulting excess demands are then totalled and international prices adjusted to move world markets towards clearance. The procedure is then repeated until a satisfactory degree of market clearance has been achieved for each commodity. Thus, the model selects that series of international and domestic prices, production, consumption, and closing stock levels which clear all markets in each successive year, from 1981 to 1990. Once 100 simulations of this type have been completed, each using a different set of generated random disturbances from the distributions of each error term, forecast means and standard deviations are calculated for all key variables in the model for each year of the simulation period.

Table A1 The Model

Consumption:

$$c_{ilt} = c_{i10}^T \left( \frac{N_{ilt}}{N_{i10}} \right) \left( \frac{y_{ilt}}{y_{i10}} \right)^{n_{ilt}} \prod_j \left( \frac{p_{jlt}}{p_{j10}} \right)^{a_{ijl}} \quad (1)$$

Production:

$$q_{ilt} = q_{i10}^T \prod_j \left\{ \left( \frac{p_{jlt}}{p_{j10}} \lambda_{ilt} \right)^{b_{1ijl}} \left( \frac{p_{jlt-1}}{p_{j10}} \lambda_{ilt-1} \right)^{b_{2ijl}} \left( \frac{p_{jlt-2}}{p_{j10}} \lambda_{ilt-2} \right)^{b_{3ijl}} \right\} \quad (2)$$

Partial adjustment to target,  $q^*$ :  $q_{ilt} = q_{i10}^T \left( \frac{q_{ilt-1}}{q_{i10}^T} \right) \left( \frac{q_{ilt}^*}{q_{i10}^T} / \frac{q_{ilt-1}}{q_{i10}^T} \right)^{\delta_{iil}} e^{\epsilon_{ilt}}$  (3)

Production shifter:  $q_{ilt}^T = q_{i10}^T e^{g_{ilt}^T}$  (4)

Change in producer/consumer price ratio:  $\lambda_{ilt} = (\rho_{ilt}^P / \rho_{ilt}^C) / (\rho_{i10}^P / \rho_{i10}^C)$  (5)

Random disturbances:  $\epsilon_{ilt} \sim N(0, U_i)$  (6)

Closing stocks:

$$s_{ilt} / z_{ilt} = \alpha_{iil} [ p_{ilt+1}^S - (1 + r_l) p_{ilt}^S - \theta_l (s_{ilt} / \bar{s}_{ilt-1}) ] + \beta_{iil} [ q_{ilt} + s_{ilt-1} - \bar{q}_{ilt} - \bar{s}_{ilt} ] / z_{ilt} + \gamma_{iil} \quad (7)$$

Price transmission:

$$p_{ilt} = \rho_{ilt}^C x_l h_{il} \bar{p}_{i10} \left( \frac{p_{ilt-1}}{\rho_{ilt-1}^C x_l h_{il} \bar{p}_{i10}} \right)^{1-\phi_{ilt}} \left( \frac{p_{ilt}}{\bar{p}_{i10}} \right)^{\phi_{ilt}} \quad (8)$$

Net imports:

$$m_{ilt} = c_{ilt} + s_{ilt} - q_{ilt} - s_{ilt-1} \quad (9)$$

Net-trading aggregates:

Target imports:  $m_{ilt}^* = m_{i10}^T + b_{iil} (p_{it} - \bar{p}_{i10})$  (10)

Partial adjustment:  $m_{ilt} = m_{i10}^T + m_{ilt-1} - m_{ilt-1}^T + \delta_{iil} [m_{ilt}^* - m_{ilt}^T - (m_{ilt-1} - m_{ilt-1}^T)] + \epsilon_{ilt}$  (11)

Net import shifter:  $m_{ilt}^T = c_{i10}^T \left( \frac{N_{ilt}}{N_{i10}} \right) \left( \frac{y_{ilt}}{y_{i10}} \right)^{n_{ilt}} - q_{i10}^T e^{g_{ilt}^T}$  (12)

International market clearing:  $\sum_l^n m_{ilt} = 0$  (13)

Table A1 (Continued) Nomenclature

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Quantities:

$c_{ilt}$  = consumption (domestic disappearance) of commodity  $i$  in country  $l$  in year  $t$ .

$c_{i10}^T$  = trend consumption of  $i$  in country  $l$  in the base year, 1980.

$q_{ilt}$  = production of commodity  $i$  in country  $l$  in year  $t$ .

$q_{ilt}^T$  = trend production of commodity  $i$  in country  $l$ . For  $t=0$  this is trend production in 1980. For  $t>0$  this would be trend production if producer prices were to remain constant.

$\bar{q}_{ilt}$  = an equally-weighted moving average of production in the three years prior to and including  $t$ .

$m_{ilt}$  = net imports of commodity  $i$  to country  $l$  in year  $t$ .

$m_{ilt}^T$  = trend net imports of  $i$  to country or country-aggregate  $l$  in year  $t$ . For  $t=0$  this is the trend of net imports in 1980. For  $t>0$  this would be trend net imports were the border price to remain constant.

$z_{ilt}$  = denominator in storage equation; equal to  $\bar{q}_{ilt}$  where commodity  $i$  is not imported, and to an equally weighted moving average of consumption where the commodity is imported.

$\epsilon_{ilt}$  = random disturbance to the production of  $i$  in country  $l$ , or to the net imports of  $i$  to country aggregate  $l$ , in year  $t$ .

$U_l$  = variance-covariance matrix of random disturbances to the production or (in the case of country aggregates) net imports of all commodities  $i$  (from 1 to  $m$ ) in country  $l$ .

$s_{ilt}$  = closing stock of commodity  $i$  in country  $l$  in year  $t$ .

$\bar{s}_{ilt-1}$  = equally-weighted moving average of closing stocks of commodity  $i$  in the three years prior to  $t$ .

Prices:

$P_{ilt}$  = domestic wholesale price of  $i$  in country  $l$  in year  $t$ .

$\bar{P}_{i10}$  = average domestic wholesale price in the years 1978 through 1980.

$P_{ilt}^S$  = price at which stocks are traded. Depending on the commodity and the country this may be either the border price or the domestic wholesale price - which ever gave the best econometric results.

$P_{ilt+1}^S$  = expected stock trading price in year  $t+1$ . In the version of the model presented here, this is set to a four-year equally-weighted moving average of stock trading prices, including the price in year  $t$ .

$P_{it}$  = standard international trading price of commodity  $i$  in year  $t$ , based on f.o.b. export prices at the major ports in Thailand (rice), Canada (wheat), USA (maize), Australia (beef) and USA (pork and poultry).

$\bar{P}_{i0}$  = average standard international price in the years 1978 through 1980.

Fixed parameters:

$\eta_{il}$  = income elasticity of demand for commodity  $i$  in country  $l$ .

$a_{ijl}$  = the elasticity of the demand for  $i$  with respect to the price of  $j$  in country  $l$ .

$b_{ijl}$  = elasticities of the target-level of production of  $i$  with respect to the producer price of  $j$ .

$b_{1ijl}$  = very short-run supply elasticity - non-zero only for ruminant meats.

$b_{2ijl}$  = one-year response elasticity.

$b_{3ijl}$  = two-year response elasticity - non-zero only for ruminant meats.

$\delta_{il}$  = partial adjustment elasticity in the production (net import) of  $i$  in country (aggregate)  $l$ .

$g_{il}$  = growth rate in the trend of production of commodity  $i$  in country  $l$  which would be sustained with constant real producer prices.

$\theta_{l,t}$  = average cost of cereal storage in country  $l$  at stock level  $\bar{s}_{ilt-1}$ .

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Table A1 (Continued)

Fixed

parameters

(continued):  $\alpha_{iL}, \beta_{iL}, \gamma_{iL}$  = estimated parameters determining the response of closing stocks to expected profits, a quantity trigger and working storage requirements, respectively.

$x_L$  = the exchange rate of country  $L$  in domestic currency per US\$(1980).

$h_{iL}$  = the ratio of the import or export unit value of commodity  $i$  in country  $L$  to the standard international price,  $P_{i0}$ , reflecting shipment costs, quality differences and access to concessional sales, in the base period, 1978-80. These divergences from the standard prices are assumed to remain constant throughout all simulations.

$r_L$  = the real rate of interest in country  $L$ .

Exogenously

projected

variables:

$N_{Lt}$  = the population of country or aggregate  $L$  in year  $t$ .

$y_{Lt}$  = the per capita income in country or aggregate  $L$  in year  $t$ .

Exogenous

policy

variables:

$\rho_{iLt}^C$  = the ratio of domestic wholesale to border price of commodity  $i$  in country  $L$ . This is unity minus the rate of consumer subsidy on the purchase price of the commodity.

$\rho_{iLt}^P$  = the ratio of domestic producer to border price of commodity  $i$  in country  $L$ . This is the familiar nominal protection coefficient. The time subscript refers to the intertemporal changes due to the phased introduction of a new policy.

$\phi_{iLt}$  = the short run elasticity of price transmission permitted by the government of country  $L$  between the domestic and international prices of commodity  $i$ . In the formulation given in equation (8) the corresponding long run transmission elasticity is unity.

Table A2 Welfare Measures

Consumer benefit from a policy change:

Expected Equivalent Variation (linear approximation)<sup>a</sup>:  $B_{lt}^C = E \{ v_{lt}^{New} - v_{lt}^{Ref} \}$  (14)

Where:  $v_{lt} = -\frac{1}{2} c_{lt}' A_l^{-1} c_{lt} - \left( -\frac{1}{2} c_{lt}' A_l^{-1} c_{lt}^u \right)$  (15)

Slutsky Matrix approximation<sup>b</sup>:  $A_l = [ a_{ijl}^c \ c_{ilt} \ / \ p_{jlt} ]$  (16)

Compensated price elasticities:  $a_{ijl}^c = a_{ijl} + n_{ijl} \frac{p_{jlt} \ c_{jlt}}{N_{lt} \ y_{lt}}$  (17)

Utility-constant consumption<sup>c</sup>, at prices  $\bar{p}_{l0}$ :  $c_{lt}^u = c_{lt} + A_l (\bar{p}_{l0} - p_{lt})$  (18)

Trend consumption:  $c_{ilt}^T = c_{i0}^T \left( \frac{N_{lt}}{N_{l0}} \right) \left( \frac{y_{lt}}{y_{l0}} \right)^{n_{iil}}$  (19)

Producer benefit from a policy change:

The expected change in producers' surplus<sup>d</sup>:  $B_{lt}^P = E \{ S_{lt}^{New} - S_{lt}^{Ref} \}$  (20)

Where:  $S_{lt} = \sum_i ( q_{ilt} p_{ilt}^P - C_{ilt} )$  (21)

Ex post producer price:  $p_{ilt}^P = p_{ilt} ( p_{ilt}^P / p_{ilt}^C )$  (22)

Production cost:  $C_{ilt} = \int_{k_{ilt}}^{\hat{q}_{ilt}} p_{ilt}^* dq_{ilt}$  (23)

Planned (expected) production<sup>e</sup>:  $\hat{q}_{ilt} = q_{ilt} e^{-\epsilon_{ilt}}$  (24)

Planning prices to achieve expected output  $q_{lt}$  (linear approximation):  $\bar{p}_{lt} = B_l^{-1} ( q_{lt} - f_{lt} )$  (25)

Linear supply response matrix:  $B_l = [ b_{ijl} ]_l = [ ( b_{1ijl} + b_{2ijl} + b_{3ijl} ) q_{ilt}^T / \bar{p}_{j0}^P ]$  (26)

Linear production intercept:  $f_{il} = q_{ilt}^T [ 1 - \sum_j ( b_{1ijl} + b_{2ijl} + b_{3ijl} ) ]$  (27)

Lower integration bound:  $k_{ilt} = \text{Max} \{ 0, f_{il} + \sum_{j \neq i} b_{ijl} p_{jlt}^* \}$  (28)

Government revenue benefit from a policy change:

Expected change in net revenue from taxes and subsidies:  $B_{lt}^G = E \{ G_{lt}^{New} - G_{lt}^{Ref} \}$  (29)

Where:  $G_{lt} = \sum_{i \in M} G_{ilt} + \sum_{i \in X} G_{ilt}$  (30)

Table A2 (Continued)

Net revenue on imported commodities: 
$$G_{ilt} = m_{ilt} ( p_{ilt} - x_{l^h} p_{ilt} ) + q_{ilt} ( p_{ilt} - p_{ilt}^P ) \quad (31)$$

Net revenue on exported commodities: 
$$G_{ilt} = - m_{ilt} ( x_{l^h} p_{ilt} - p_{ilt}^P ) + c_{ilt} ( p_{ilt} - p_{ilt}^P ) \quad (32)$$

Benefit to holders of grain stocks of a policy change:

Expected change in profits: 
$$B_{lt}^S = E \left\{ \sum_i^m ( R_{ilt}^{New} - R_{ilt}^{Ref} ) \right\} \quad (33)$$

Intra-year profit on i: 
$$R_{ilt} = x_{l^h} p_{ilt} ( s_{it-1} - s_{it} ) - \theta_L ( s_{ilt} / \bar{s}_{ilt-1} ) s_{ilt} \quad (34)$$

Total welfare impact of a policy change:

The sum of the component benefits: 
$$W_{lt} = B_{lt}^C + B_{lt}^P + B_{lt}^G + B_{lt}^S \quad (35)$$

Net trading aggregates: 
$$W_{lt} = E \left\{ S_{lt}^{New} - S_{lt}^{Ref} \right\} \quad (36)$$

Where  $S_{lt}$  is the area under the single-commodity excess demand curve:

$$S_{lt} = \frac{1}{2} \sum_i^m ( m_{ilt}^2 / b_{il} ) \quad (37)$$

Variables not defined in Table A1:

- $c_{lt}$  = an m-component vector of total consumption levels (direct consumption plus consumption by livestock) in country  $l$  in year  $t$ .
- $q_{lt}$  = an m-component vector of production levels in country  $l$  in year  $t$ .
- $p_{lt}$  = an m-component vector of consumer prices in country  $l$  and year  $t$ .
- $\varepsilon_{lt}$  = an m-component vector of random disturbances to production in country  $l$  and year  $t$ . These are derived as the exact additive equivalents of the multiplicative disturbances applied to equation (3) of Table A1.
- $b_{il}$  = the slope of the linear target excess demand function for commodity  $i$  of net-trading aggregate  $l$ .

- <sup>a</sup> In this non-linear, multivariate and stochastic model, the Equivalent Variation (EV) is estimated using a linear approximation. Compensated demand elasticities are evaluated at the endogenous prices,  $p_{lt}$ , and used to assemble the local Slutsky Matrix of compensated demand coefficients. A linear, utility-constant demand function is then drawn through  $(p_{lt}, c_{lt})$  and the EV is measured relative to the base period prices,  $p_{l0}$  (which are the same for every simulation). The consumer benefit, associated with some *New* set of simulations which incorporate a policy change, is then the expected value of the *New* EV (relative to the base period prices,  $p_{l0}$ ) minus the expected value of the *Reference* EV (also evaluated relative to the base period prices). This indirect method of calculating the consumer benefit helps to minimize the errors associated with the linear approximation. Note also the embedded assumption that consumers are risk neutral.
- <sup>b</sup>  $A_l$  excludes the terms linking grain consumption to meat prices since these represent the consumption behaviour of the livestock sector and only direct consumption parameters are relevant here.
- <sup>c</sup>  $c_{lt}^u$  excludes the consumption of grain by livestock. This is assumed to make up a fixed proportion of coarse grain consumption, set separately for each country.
- <sup>d</sup> Producer surplus is evaluated as the difference between a *a posteriori* revenue at the endogenous producer prices and production levels  $(p_{lt}, q_{lt})$  and the cost associated with planned production.
- <sup>e</sup> Note that planned production differs from the Nerlovian target production of equation (2). It is the level of production which would be expected to occur in the absence of the random disturbance introduced in equation (3).

TABLE A3

Essential Production, Consumption and Policy Parameters for the European Community

Commodity	Trend consumption 1980 (10 <sup>3</sup> tons) of demand	Income elasticity of demand	Elasticity of demand w.r.t. price of:				Trade Policy Parameters				Projected growth rates (%/yr)		
			R	W	CG	RM	NRM	Nominal Coefficient	Elasticity of Price Transmission	$\phi_t$	Interval	Population	GDP
Rice	988	.11	-.50	.80	.10			1.47	.0	1980-83	.2	1.5	
Wheat	44,840	-.10	.01	-.42	.30	.07	.07	2.10	.0	1984-86	.2	2.2	
Coarse grain	75,024	.40	.10	-.73	.21	.24		1.83	.0	1987-90	.2	3.0	
Ruminant meat	7,355	.40			-.70	.32		1.94	.09				
Non-ruminant meat	12,443	.55			.20	-.70		1.40	.24				

Commodity	Trend production 1980 (10 <sup>3</sup> tons)	Price-constant production growth rate (%/Yr)	Long run elasticity of supply w.r.t. the price of:				Short run elasticity of supply w.r.t. the price of:				Disturbance standard deviation			
			R	W	CG	RM	NRM	R	W	CG		RM	NRM	
Rice	648	.5	.40										.15	
Wheat	49,680	1.5		.90	-.66			.30	-.15					.13
Coarse grain	68,212	1.5		-.34	.91			-.15	.40					.07
Ruminant meat	7,260	1.5			-.30	-.70	-.48	.10	-.20	.06	.17	-.16		.05
Non-ruminant meat	12,670	2.0			-.30	-.75	-.30	1.00		-.033	.33			.03