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INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS
BASIC LINKED SYSTEM WORLD AGRICULTURAL MODEL

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In this report, a brief overview of the results of three scenario runs is given. These are the reference scenario, multilateral trade liberalization in agriculture, and a 1-year, 5-percent reduction in U.S. crop production. Although the description of the reference run is given for a period longer than 5 years, the impacts of the other two scenarios are discussed for up to 5 years after introducing the required changes. The analysis more or less adheres to this elapsed time to facilitate the comparison of our results with those obtained with other models. The 5-year period is too short for the multilateral trade liberalization scenario, however, to get all the adjustments completed.

The description omits many details to keep the report at a reasonable size. 1/ Emphasis is put on the results obtained for those developed market economies that are included in the Basic Linked System (BLS) of the International Institute for Applied System Analysis (IIASA) with a separate model for each. Together with Argentina, these are the countries that constitute a large part of the trade in temperate zone food products and that are of primary interest at this meeting.

The BLS is an empirically estimated model system. 2/ It consists of 20 detailed models built for policy analysis constituting approximately 80 percent of the world's total agricultural production, trade, land availability, and population. The remaining part of the global food and agriculture system is divided into 14 regions, each of which is represented by a simplistic model.

Klaus Frohberg is with the International Institute for Applied Systems Analysis in Laxenburg, Austria. The work reported in this paper is part of a joint effort. The list of all those who have contributed is too large to name them all here. However, I would like to express my special thanks to those current and past members of the Food and Agriculture Program (FAP) who helped build the FAP model system to its current state, and to K. Parikh who, in addition, joined in interpreting the results. The FAP Core Group: Kirit S. Parikh (Program Leader since 1981), Ferenc Rabar (Program Leader 1976-80), Guenther Fischer, and Klaus Frohberg. Approach and Interpretation: Janos Hrabovszky, Michiel Keyzer, Mahendra Shah, and T. N. Srinivasan. Data Processing, Tabulation and Graphics: Gerhard Kroemer, Jan Morovic, Ulrike Sichra, and Laszlo Zeold.

1/ The reference scenario and that of multilateral trade liberalization will be discussed in more detail in a forthcoming book by K. Parikh, G. Fischer, K. Frohberg, and O. Gulbrandsen. The book will be entitled Toward Free Trade in Agriculture.

2/ A more detailed description of the model system can be found in Keyzer, M. A. The International Linkage of Open Exchange Economies, doctoral dissertation, Free University of Amsterdam (1981); Frohberg, K., and G. Fischer. A Detailed Description of the Supply and Policy Components of a National Model in the Basic Linked System of the Food and Agriculture Program of IIASA: Using the Canadian Agricultural models as an Example, internal paper, IIASA, Laxenburg, Austria (1985); Fischer, G. Human Demand System in the Basic Linked System, internal paper, IIASA, Laxenburg, Austria (1985).

Not all of the detailed models have a structure similar to the one discussed in this report. Among those with a different structure are the models for China, the Council for Mutual Economic Assistance (CMEA), India, and the United States. The China model, used mainly for consistency checking, has been constructed on a limited information basis and, therefore, does not provide all desired characteristics for an in-depth analysis (5). 3/ The CMEA model is an aggregated version for all European CMEA countries including the Soviet Union (2). The CMEA model focuses on the long-term prospects of these countries and includes many planning features. The Indian model determines supply by allocating land, fertilizer, and capital to the various commodities and demand by distinguishing 10 income classes. The consumption patterns of those are described by Linear Expenditure Systems (4). The U.S. model includes a conventional supply module for output determination and a Linear Expenditure System for calculating the consumption level (1).

The following countries are represented in the BLS by models with a common structure: Argentina, Australia, Austria, Brazil, Canada, Egypt, Indonesia, Japan, Kenya, Mexico, New Zealand, Nigeria, Pakistan, Thailand, Turkey, and the European Community (EC). The EC is modeled by aggregating all member countries except Greece. Greece is not included in the EC model but is in one of the regional models.

Of the 14 regional models, 13 deal with developing countries only. The grouping of these regions is based on geographic considerations, income level, and the country's position as an exporter or importer of calories. In this way, five regions have been identified for Africa, three for Latin America, three for Far East Asia, and two for Near and Middle East Asia. In principle, these regional models follow an exogenously specified supply and demand pattern taken from scenario B of the Food and Agriculture Organization study Agriculture: Toward 2000. Deviations from those trends are possible, however, if the price structure at the world market changes from the base year. For this purpose, own- and cross-price elasticities of supply and demand derived from results of detailed models for developing countries are introduced in each of these 13 regional models.

One regional model includes all countries not otherwise represented in the BLS. Although the number of countries included is large, this regional model is dominated by developed countries, most of them belonging to Europe. The basic trend in production and demand is determined by growth rates derived from observations. Deviation from trend might occur the same way as for the other regional models.

The model system is of the general equilibrium type. Money is assumed to be neutral. The implication of this assumption is that effects of inflation and exchange rate changes cannot be investigated. Care has been taken in modeling the responses of various actors in the system; that is, of governments, producers, and consumers. A mutual dependence in the behaviors of these actors is built in through several linkages and through the imposition of the accounting identities of quantity and financial flows.

Prices are endogenously calculated in the model system for the domestic markets and the world market. Both producers and consumers respond to changes

3/ Underscored numbers in parentheses refer to sources cited in the References.

in relative prices. The government has a wide range of policy instruments at its disposal (taxes, income transfers, subsidies, procurement, rationing, and a set of instruments dealing with international trade).

The model system provides us with annually calculated information on quantities produced, demanded, traded, and stockpiled and with a set of prices. This set of information is consistent in the sense that all quantities balance as well as all financial transactions.

Table 1 lists the commodities in which international trade is carried out and their composition.

Table 1--The Basic Linked System commodity list of international exchange

Commodity	Unit of measurement	Components
	Million metric tons	
Wheat	Wheat equivalent	Wheat and wheat flour
Rice	Milled equivalent	
Coarse grains	Coarse grain equivalent	Corn, sorghum, barley, oats, rye, millet, other grains, and coarse grain flour
Ruminant meat	Carcass weight	Meat from cattle, sheep, goats, buffalo, donkeys, camels, horses, and game
Dairy products	Fresh milk equivalent	
Other animal products	Protein equivalent	Pork, poultry, eggs, and fish
Protein feed	Protein equivalent	Oilseed meal and cake, fish meal, and meat meal
	Billion 1970 U.S. dollars	
Other food		Fats and oils, roots and tubers, pulses, sugar products, vegetables, nuts, fruits, cocoa, coffee, tea, beverages, and other food
Nonfood agriculture		Fibers, hides, tobacco, and other industrial crops
Nonagriculture		Gross domestic product outside agriculture

A Brief Description of the Reference Scenario

The reference scenario, which we designate RO, may first be characterized by its endogenously generated economic growth rates in relation to recent historical experience. The growth rates of some important aggregates are shown in table 2. As far as it applies, the growth rates referred to in this section are all at constant 1970 prices.

The global gross domestic product (GDP) growth rate falls in the RO from 4.5 percent per year over the seventies to 4 percent per year during the last two decades of this century. The deceleration in growth can be found only for developed countries, whereas the developing country group as a whole shows steady growth of 5.4 percent per year.

Compared with the historical performance in the seventies, the BLS growth rates are higher than the realized ones for developed countries (both

Table 2--Growth rates of population, gross domestic product (GDP), calorie intake, agricultural value added, and agricultural trade balances, reference scenario, 1970-2000

Item	World	OECD	CMEA	Developing countries (excluding China)
		Percent per year		
Population growth:				
1970-80	1.9	0.8	0.9	2.5
1980-90	1.8	.8	.8	2.5
1990-2000	1.7	.7	.7	2.3
Gross domestic product growth:				
1970-80	4.6	4.1	5.7	5.4
1980-90	4.1	3.5	4.8	5.4
1990-2000	3.7	3.0	4.0	5.5
Gross domestic product per capita growth:				
1970-80	2.7	3.3	4.8	2.8
1980-90	2.3	2.7	3.9	2.9
1990-2000	2.0	2.2	3.2	3.1
Calories per capita growth:				
1970-80	0	0	.5	.5
1980-90	0	0	0	.7
1990-2000	0	0	-.2	.6
Agricultural value added growth:				
1970-80	2.5	2.1	3.0	2.4
1980-90	2.2	1.2	2.4	3.0
1990-2000	2.3	.9	2.8	2.9
Agricultural trade balance as a fraction of value added in agriculture:		Percent		
1980	0	6.3	-2.2	4.7
2000	0	9.9	-1.8	1.3

Organization for Economic Cooperation and Development (OECD) and CMEA) but very close to the realized one for developing countries as a group. It should, however, be noted that the RO has not taken into account the effect of the 1979 oil crisis on growth.

The world agricultural value added also decelerates over the 1980-2000 period, although less strongly than GDP, below the growth rate of 2.5 percent per year in the seventies in the reference run simulation (table 2). The deceleration is mainly due to a fall in the OECD growth rate of agriculture from 2.1 percent per year over the seventies to 0.9 percent per year over the nineties. This fall may be expected due to two factors: slower population growth and a tendency for food intake saturation with growing income. The growth rate of agricultural output in OECD countries, thus, could have been maintained only by increasing exports. And, in fact, agricultural supply surplus of OECD countries increases by almost 50 percent from 6.3 percent of GDP agriculture in 1980 to 9.9 percent of GDP agriculture in 2000. Larger agricultural exports by OECD countries would have depressed world market prices and, hence, lowered the incentives to maintain growth rates comparable to the high growth rates in agriculture observed in 1970. Moreover, in our scenario, the EC pursues a moderate agriculture price policy, and, therefore, labor migrates out of agriculture at a rather high rate and the capital stock in agriculture also grows slowly. The United States also shows a strong decline in agricultural growth for similar reasons.

Developing countries as a group accelerate their agricultural growth rate from 2.4-3 percent per year. This higher growth is, however, insufficient to meet demand, due both to continued population growth of about 2.5 percent per year and sustained growth of about 3 percent per year income per capita. Thus, one observes for developing countries, excluding China, a strong increase in their net imports of cereals, from 37 million metric tons (MMT) in 1980 to 120 MMT in 2000 to satisfy their staple food needs (table 7). It should be noted that this expansion concerns effective imports, realizable within the balance-of-payment framework prescribed by the assumed trade deficit targets (developing country trade deficit being around 3 percent of their GDP).

While their imports of cereals increase, the developing countries are unable to increase adequately their exports of tropical food and fibers because of slow demand growth in the main export markets, namely the developed countries. These developments result in a reduction of the agricultural trade balance of the developing countries, from a 4.7-percent surplus in 1980 to a 1.3-percent surplus in 2000 expressed as a percentage of agricultural GDP.

World Market Price Trends in the Reference Scenario

Prices given in this paper are all relative to the price of nonagricultural goods. The growth rates of world market prices over various periods are shown in table 3. The last line of table 3 indicates the terms of trade for agriculture as a whole as a weighted average of commodity prices, weighted by the volumes produced. The terms of trade for agriculture increase by 0.4 percent per annum over the period 1980-2000 which is because the increase observed during the seventies.

The most striking long-term trend of the world market prices in the period 1980-2000 is, according to the RO, a price rise of ruminant products (meat and milk), amounting to about 2 percent per year in real terms (table 3). Two

Table 3--Changes in world market prices for agricultural products relative to nonagricultural prices, according to the reference scenario, 1980-2000

Commodity	Total price change			Annual price change,
	1980-1990	1990-2000	1980-2000	1980-2000
	Percent			
Wheat	2	-10	-8	-0.4
Rice	-4	5	1	.1
Coarse grains	1	-11	-10	-.5
Bovine and ovine meat	28	20	53	2.2
Dairy products	23	11	37	1.6
Other animal products	5	1	6	.3
Protein feed	2	-4	-2	-.1
Other food	1	4	5	.2
Nonfood agriculture	20	4	25	1.1
Total agriculture 1/	5	3	9	.4

1/ Aggregated using global production levels.

reasons can be given for this price rise. From the demand point of view income elasticities for meat are high in the developing countries where incomes grow at high rates. On the supply side, production costs may be expected to go up relatively strongly in some land-scarce countries due to an increase in feeding cost because the opportunity cost of land for roughage production move up. Expansion of cropland encroaches upon the grassland that provides cheap fodder for the ruminants. The ensuing shift to more expensive feeds in the ruminant diet may cause an increase in the production cost. The rather strong increase in the world market price of bovine and ovine meat, however, is mainly due to the price policy of a few countries. The EC drops its tariff equivalent from 61 percent in 1980 to 12 percent in 2000 (table 11). This drop is strong enough to offset the increase of the world market price so that the (relative) domestic price of bovine and ovine meat does not increase. As a consequence, production of this commodity hardly increases, but demand goes up, leading to substantially higher imports by the EC. Twenty-five percent of the increase in world trade in bovine and ovine meat between 1980 and 2000 is imported by the EC. The other country with a strong rise in imports is Brazil, taking in 42 percent of the additional world trade over this period. Although Brazil does not change its tariff equivalent and, hence, the domestic price goes up similar to the world market and more than the average domestic price of agriculture, production is outpaced by demand. Among the big exporters, only Argentina and Canada respond to the increases in world market price with substantially higher exports. The United States pursues a policy of trade restriction, and Australia does not push up production.

While prices for bovine and ovine meat and dairy products rise significantly, those of other animal products (pork, poultry, eggs, and fish) rise by a very small amount, by only about 0.3 percent per year. Other animal products benefit from the relative decline in prices of the main feed items. In addition, developing countries are able to realize their potential for

considerable productivity gains for this aggregate, which requires less investment than those for ruminants. Hence, the increase in production of this commodity is large enough to meet the increased demand with only a small increase in price.

Another interesting long-term trend is the continued fall in the relative prices of wheat and coarse grains. The fall takes place during the nineties. Protein feed, on the other hand, shows virtually no change in its price (a small reduction) in spite of the higher prices of animal products. The higher animal product prices do not get translated into a larger demand for protein feed, the demand for which increases only modestly by 2.0 percent per annum. This is because cheaper feed grains compete with protein feed in pork and poultry production, and in ruminant production protein feeds are relatively expensive substitutes for roughage.

Production of wheat grows at an annual rate exceeding 3 percent and protein feed at nearly 2.5 percent over 1980-2000 in the developing countries excluding China (table 5). Even then the developing countries increase their imports of wheat and coarse grains.

Nonfood products, that is, mainly fibers, hides and skins, tobacco, show a clear upward price trend, particularly in the eighties. The main reason is the quite strong expansion of demand from the socialist block and the developing countries in our RO, which materializes as a result of high overall economic growth in these countries. Prices of rice, other animal products, and other food, mainly oils and fats, sugar, vegetables, fruits, and beverages, do not change significantly.

In summary, one could say that the price changes are relatively small indeed in all commodities. This indicates that substitution possibilities in demand and supply are large enough in the world food system, and supplies are able to meet effective demand, that is, demand backed by purchasing power, at reasonable costs.

Shifts in Demand and Production Structures

The changing global pattern of demand can be seen in table 4. The growth rates of demand for the various agricultural commodities differ significantly from each other. Demand for other animal products grows at 2.3 percent per year whereas demand for bovine and ovine meat and dairy products grow at 1.5 and 1.6 percent per year, respectively. The share of various country groups in global demand also changes significantly between 1980 and 2000. As can be seen in table 4, the share of developing countries in global demand increases significantly for all commodities except rice and nonfood agriculture. The demand increase in developing countries for meat is satisfied by local production. Only imports of dairy products expand substantially, doubling over the 20-year period (table 7). The dairy imports mainly increase in Nigeria and Pakistan and to some extent in Brazil, Egypt, and India. Developing countries generally have a comparative disadvantage in producing feed grains. Hence, almost all (90 percent) of the large increase in grains needed for feeding is imported. If one excludes China in this calculation, then all feed (60 MMT) additionally required between 1980 and 2000 must be imported.

The growth rate of production of various commodities differs globally and for various country groups. Table 5 shows the structure of production in year

Table 4--Agricultural demand in the reference scenario, 1980 and 2000

Commodity	Global demand			Share in global demand							
				DME 1/		DEV 2/		CMEA 3/		China	
	1980	2000	Growth	1980	2000	1980	2000	1980	2000	1980	2000
	Million metric tons			Percent							
Wheat	439	635	1.9	23.6	21.3	27.5	37.5	33.4	26.7	12.3	11.4
Rice 4/	252	380	2.1	6.4	5.3	56.1	65.8	.7	.6	36.7	28.2
Coarse grains	787	1,109	1.7	42.4	43.7	20.4	27.0	23.5	18.7	10.0	9.5
Bovine and ovine meat	63	86	1.5	49.3	43.3	28.9	36.1	16.9	15.0	5.9	5.9
Dairy products	470	642	1.6	44.5	39.0	23.1	31.6	30.1	26.6	1.4	2.0
Other animal products 5/	17	27	2.3	41.7	37.8	20.5	28.4	15.1	9.1	18.8	22.3
Protein feed 5/	42	62	2.0	50.2	48.5	14.7	21.1	8.9	6.2	11.7	12.6
	Billion 1970 U.S. dollars										
Other food	228	344	2.1	21.8	18.0	42.4	52.6	15.1	11.1	15.8	14.4
Nonfood agriculture	26	41	2.3	35.4	26.1	30.4	30.7	26.8	30.5	14.7	17.3
Nonagriculture	5,562	11,513	3.7	78.8	71.3	9.0	13.9	7.8	8.8	4.1	5.8

1/ Developed market economies.
2/ Developing countries, excluding China.
3/ Council for Mutual Economic Assistance.
4/ Milled equivalent.
5/ Protein equivalent.

Table 5--Agricultural production growth in 1980-2000, and levels and distribution among major country groups in 2000: Reference scenario volumes in year 2000

Commodity	World	NA + OCE 1/	E + JAP 2/	CMEA 3/	China	DEV 4/
			Million metric tons			
Wheat	619	156	85	150	47	175
Rice 5/	362	9	15	2	90	244
Coarse grains	1101	410	154	196	98	237
Bovine and ovine meat	86	20	16	13	5	31
Dairy products 6/	642	105	171	172	13	179
Other animal products 7/	27	3	8	2	6	7
			Billion 1970 U.S. dollars			
Protein feed 7/	62	29	4	4	8	18
Other food	347	20	38	37	54	195
Nonfood agriculture	41	5	3	10	7	15
Growth rates, 1980-2000:			Percent per year			
Wheat	1.9	2.8	1.1	0.8	1.1	3.3
Rice	2.1	3.4	.7	2.1	.6	2.9
Coarse grains	1.8	2.4	1.4	.6	1.5	2.1
Bovine and ovine meat	1.5	.9	1.0	.9	1.4	2.8
Dairy products	1.6	1.5	.9	.9	3.8	3.1
Other animals	2.3	1.1	2.1	-.3	2.9	3.9
Protein feed	1.9	1.7	1.6	1.3	1.8	2.8
Other food	2.1	1.4	.9	.4	1.7	3.1
Nonfood Agriculture	2.3	1.3	.7	3.0	3.2	2.3
Value share of total agriculture, 2000:			Percent			
Wheat	4.8	9.1	4.3	8.8	2.5	3.1
Rice	6.9	1.2	1.8	.3	11.9	10.7
Coarse grains	6.6	18.6	6.1	8.9	4.1	3.3
Bovine and ovine meat	9.1	16.3	11.5	10.4	3.7	7.6
Dairy products	8.2	10.2	14.4	16.6	1.2	5.3
Other animals	15.6	14.6	29.1	10.7	23.9	10.0
Protein feed	2.0	7.1	.8	.9	1.7	1.3
Other food	41.6	17.8	29.8	33.4	44.7	54.1
Nonfood agriculture	5.3	5.0	2.3	10.1	6.3	4.5

1/ Canada, United States, Australia, and New Zealand.
2/ Austria, EC, Japan, and all other developed market economies.
3/ Council for Mutual Economic Assistance.
4/ All developing countries, excluding China.
5/ Milled equivalent.
6/ Milk equivalent.
7/ Protein equivalent.

2000 for various country groups and also indicates the commodity growth rates over 1980-2000. Though the production patterns change, the country groups continue to remain dominant in particular commodities in which they were dominant. Thus, North America and Oceania remain major producers of wheat, coarse grains, and protein feed. European developed market economies and Japan continue to produce more than a quarter of the world's dairy production, and developing countries continue to remain as major producers of other food and nonfood agriculture.

The value shares of domestic agricultural production in world agricultural production (table 6) show that the shares of most large countries or country groups (China, CMEA, EC, and United States) decline, those of Brazil, India, and Japan more or less remain constant, and all other less developed country (LDC) producers improve their shares.

The general picture of agricultural production development that is described in the RO shows no dramatic shifts in global specialization, but the major

Table 6--Value shares of domestic agricultural production in world agricultural production, 1980 and 2000 1/

Country	1980	2000
	Percent	
North America and Oceania:		
United States	11.10	10.02
Canada	1.39	1.42
Australia	1.15	1.23
New Zealand	.40	.46
Other developed countries:		
Austria	.25	.22
EC	9.27	7.49
Japan	2.92	3.00
Centrally planned economies:		
CMEA 2/	16.68	13.17
China	15.22	14.35
Developing market economies:		
Argentina	1.41	1.51
Brazil	3.88	3.95
Mexico	1.20	1.71
Egypt	.73	.87
Kenya	.24	.39
Nigeria	1.94	2.64
Indonesia	1.76	1.88
Pakistan	.87	1.20
Thailand	.99	1.08
Turkey	1.77	1.93

1/ Gross value of production at world prices. The value share of India and the rest of the world country groups is not reported.

2/ Council for Mutual Economic Assistance.

producers increase their production at smaller rates than that at which global production rises and the smaller countries do so at rates that are higher than the global one.

Changing Patterns of Trade

The past trends of changing trade patterns continue in the reference run. The importance of trade increases, and the level of interdependence in the world increases in that not only the volumes of traded commodities increase, but also the proportions of total global production that are traded increase in the RO. This implies that growth rates of trade are higher than growth rates of production.

The pattern of trade reflected in table 7 shows that major expansion of agricultural trade takes place in the commodities expected by the developed countries of North America and Oceania. The major exports of developing countries, mainly protein feed, other food, and nonfood agriculture, increase by comparatively small amounts.

The relatively small growths in trade of other food and nonfood agriculture may also be a result of the fact that these are aggregates involving a number of commodities each and that for each national or country group model we generate only net exports, that is, exports minus imports. Thus, the growth rates of the volume of net trade in these aggregates, as generated in our scenario, underestimated gross volumes if the subaggregates are partly exported and partly imported.

The pattern of trade is affected by the trade deficits for the various countries. The trade deficits are determined every year in a a globally consistent way endogenously based on a notion of a sustainable level of deficit depending on the country's growth rate, export earning of precious years, and debt service. The resulting pattern of trade deficits is shown in table 8.

The projected trade deficits show that the developed market economies increase their trade surplus, CMEA and China are projected to maintain balanced trade, and most of the developing market economies increase their deficits or reduce their surpluses. The exceptions are Brazil, whose trade deficit of nearly $2 billion (1970 U.S. dollars) in 1980 turns into a similar surplus by the year 2000, and Mexico, Egypt, and Turkey whose trade deficits decline modestly.

The country pattern of trade is shown in table 9. Here, one sees significant changes in volumes traded and also the changing importance of commodities in a country's trade. Also, reversals of trade direction for some commodities are noticeable. Though a number of countries reverse the direction of trade in commodities in which they were marginal traders, some major reversals are also seen.

Table 10 shows the terms of trade indices for the countries for 1980 and 2000. The terms of trade index is calculated as the ratio of unit value index of exports to unit value index of imports in the current year and normalized with the ratio obtained in 1970. The fall in world market prices of wheat and coarse grains; the increase in the prices of bovine and ovine meat, dairy products, and nonfood agricultural products; and changes in the traded quantities of these commodities mostly determine the changes in the terms of

Table 7--Agricultural trade balances, reference scenario, 1980 and 2000

Commodity & year	NA+OCE 1/	E+JAP 2/	CMEA 3/	CHINA	DEV 4/
			Million metric tons		
Wheat:					
1980	61.2	2.4	-19.7	-7.3	-28.3
2000	106.0	3.4	-19.2	-13.7	-62.9
Rice:					
1980	2.9	-2.1	-.7	1.8	-3.7
2000	6.3	-3.0	-.4	1.0	-5.5
Coarse grains:					
1980	69.1	-26.1	-13.0	-1.7	-5.2
2000	155.8	-73.5	-12.0	-1.8	-62.0
Bovine and ovine meat:					
1980	.2	-.9	-0	.1	-.4
2000	.7	-1.2	0	-0	-.1
Dairy products:					
1980	4.6	8.8	.6	-.6	-12.1
2000	16.2	9.0	.8	.4	-23.9
Other animal products: 5/					
1980	.4	.2	-0	0.1	-.1
2000	.3	.6	0	-0	-.2
Protein feed: 5/					
1980	11.2	-9.2	-.8	.4	4.1
2000	16.1	-13.8	0	-.1	4.7
			Billion 1970 U.S. dollars		
Other food:					
1980	2.1	-5.5	-.3	1.2	10.3
2000	3.1	-7.6	-1.5	2.1	13.8
Nonfood agriculture:					
1980	1.1	-3.9	-1.2	-0	1.8
2000	1.4	-4.2	-2.1	0	2.8

1/ Canada, United States, Australia, and New Zealand.
2/ Austria, EC, Japan, and all other developed market economies.
3/ Council for Mutual Economic Assistance.
4/ All developing countries.
5/ Protein equivalent.

trade. Brazil, Indonesia, Nigeria, and Pakistan either increase imports or decrease exports of these products that increase in price and, thus, suffer a loss of terms of trade. India, on the other hand, increases its imports of bovine and ovine meat and dairy products as well as its exports of wheat. The loss in terms of trade is partly compensated by its increased exports of nonfood agricultural products. Even then, its terms of trade index falls by around 8 percent from 1980-2000. Though the United States expands its export of dairy products substantially, the loss due to a fall in prices of wheat and coarse grains, its major exports, results in a terms of trade loss of around 8 percent. The EC's loss in terms of trade is mainly due to its reduced exports of dairy products, and the CMEA's loss is mainly due to its increased imports of nonfood agriculture.

Table 8--Net trade deficit in the reference scenario, selected years 1/

Countries	1980	1990	2000
	Million 1970 U.S. dollars		
United States	265	-5,476	-6,559
Canada	116	-673	-912
Australia	11	-195	-209
New Zealand	289	88	-2
Austria	322	16	-57
EC	385	-4,484	-6,222
Japan	-2,342	-3,122	-5,331
Argentina	-809	-289	-127
Brazil	1,968	-489	-2,001
Mexico	781	389	437
Egypt	1,191	777	1,046
Kenya	143	270	378
Nigeria	-349	-118	-124
India	1,917	2,966	5,106
Indonesia	-170	-64	-40
Pakistan	1,182	2,055	2,839
Thailand	355	478	677
Turkey	1,227	742	875

1/ A negative sign implies surplus.

In general, the countries who lose on their terms of trade are also the countries whose balance of agricultural trade, also given in table 10, declines. Exceptions from this general observations are the U. S., Canada, and Indonesia who indicate an improvement in their agricultural trade balance inspite of a decline of their terms of trade and Egypt who shows the opposite. Most countries maintain their status as either having surplus on agricultural trade or a deficit. The two exceptions are Brazil and Indonesia. Brazil's agricultural surplus changes into a modest deficit by the year 2000, whereas Indonesia's small surplus becomes a sizable deficit. The U.S. agricultural trade surplus, in spite of this loss in terms of trade, continues to grow and so does EC's deficit. India's agricultural trade surplus declines, but it still remains a surplus country by the year 2000.

Agricultural self-reliance ratios, defined as the ratio of the gross value of agricultural production to value of demand for agricultural products, are also shown in table 10. These ratios indicate that, among the net agricultural importers shown in 1980, only EC and Nigeria increase their dependence on imports for agricultural products. Some of the agriculturally surplus countries do reduce their surplus from 1980-2000, but, except for Indonesia whose self-reliance ratio goes down to 0.9 from 1.02, they remain as surplus countries. Countries with substantial agricultural surplus increase their surpluses except for Brazil.

This overview of the development of trade patterns in the RO shows the increasing importance of trade and interdependence, and continuation of patterns of global specialization in most cases.

Table 9--Patterns of trade by country in the reference scenario, 1980 and 2000 1/

Country	Year	Wheat	Rice	Coarse grains	Bovine and ovine meat	Dairy products	Other animal products	Protein feed	Other food	Nonfood agriculture
		Million metric tons					Billion 1970 U.S. dollars			
United States	1980	40.1	2.7	61.8	-1.2	-1.0	0.25	11.4	2.0	--
	2000	64.8	6.2	128.3	-1.3	9.1	.01	16.2	3.0	--
Canada	1980	12.6	-.1	4.8	--	0	.14	-.2	-.3	.1
	2000	25.5	-.1	14.8	.4	--	.24	-.3	-.4	.2
Australia	1980	8.5	.2	1.9	.7	1.6	.03	.1	.3	.6
	2000	15.8	.2	12.5	.5	1.8	.02	.2	.6	.8
New Zealand	1980	.1	--	.6	.7	3.9	.01	--	0	.3
	2000	-.1	--	.2	1.2	5.3	.01	.1	-.1	.5
Austria	1980	--	--	.3	--	.4	-.01	-.1	-.1	-.1
	2000	.1	--	.4	--	.7	-.01	-.2	-.1	-2.1
EC	1980	11.2	-.3	-2.3	-.4	10.0	.05	-5.0	-4.2	-2.1
	2000	17.6	-.2	-19.6	-1.0	8.7	.08	-6.4	-7.2	-2.1
Japan	1980	-5.9	-.4	-17.4	-.3	-1.1	.06	-2.3	-1.6	-1.2
	2000	-9.4	-.8	-38.0	-.3	-.4	-.39	-3.7	-1.8	-1.4
CMEA	1980	-19.7	-.7	-13.0	--	.6	-.00	-.8	-.3	-1.2
	2000	-19.2	-.4	-12.0	--	.8	.01	--	-1.5	-2.1
China	1980	-7.3	1.8	-1.7	.1	-.6	.10	.4	1.2	--
	2000	-13.7	1.0	-1.8	--	.4	-.05	-.1	2.1	--
Argentina	1980	4.3	--	9.3	.5	--	-.01	.2	.1	.3
	2000	6.6	--	12.9	1.5	.2	.03	.2	.6	.4
Brazil	1980	-3.0	.4	--	.1	-.6	-.09	2.8	1.6	.3
	2000	-6.6	-1.0	-8.6	-1.0	-1.7	-.22	4.8	.9	.3
Mexico	1980	-.4	--	1.2	--	-.3	.03	-.1	.3	.1
	2000	-2.3	-.1	-5.7	-.1	.1	.23	-.8	.6	--
Egypt	1980	-2.7	.2	--	-.2	-.5	.01	--	.2	--
	2000	-5.0	--	-2.6	-.3	-1.6	.03	--	.3	.2
Kenya	1980	-.1	--	-.3	--	-.1	0	--	.2	.1
	2000	-.3	--	-2.0	--	--	0	--	.6	.3
Nigeria	1980	-1.0	-.2	-.6	-.2	-.6	-.08	--	-.2	--
	2000	-10.0	-1.9	-1.7	-.5	.1	.33	-.8	-.7	--
India	1980	.1	-.4	-3.8	-	-.1	0	.6	.2	.1
	2000	6.1	4.0	-10.1	-.1	-.9	-.03	.8	-.5	.2
Indonesia	1980	-.6	-.8	-.3	-.1	-.2	.02	.1	.3	--
	2000	-1.6	-2.2	-1.3	-.1	-.4	-.04	-.1	-.7	-.1
Pakistan	1980	.9	.4	.1	--	-1.5	.01	--	-.2	-.1
	2000	3.2	1.1	.7	--	-4.7	.01	.1	-.2	-.2
Thailand	1980	-.1	.4	2.2	--	-.3	.01	--	1.2	.1
	2000	-.3	1.1	2.4	.1	-.4	.02	--	1.7	.1
Turkey	1980	-1.2	--	-.4	--	.1	.01	--	.5	.3
	2000	-2.7	--	-1.7	.2	1.9	.02	--	1.2	.4

-- means a very small value.
0 means slightly larger but still less than 0.05.
-0 means slightly negative but still greater than -0.05.
1/ Negative values mean imports.

Table 10--Terms of trade, agricultural trade balance and agricultural self-reliance, 1980 and 2000

Country	Terms of trade index		Agricultural trade balance		Agricultural self-reliance	
	1980	2000	1980	2000	1980	2000
	Index 1/		Billion 1970 U.S. dollars 2/		Ratio 3/	
North America and Oceania:						
United States	0.98	0.90	9.6	15.8	1.25	1.35
Canada	1.00	.98	1.2	2.8	1.33	1.67
Australia	1.05	1.10	1.6	2.8	1.66	1.90
New Zealand	1.04	1.44	.8	1.1	2.20	2.04
Other developed countries:						
Austria	.97	.98	-.1	-.3	.91	.96
EC	.93	.87	-4.0	-6.9	.89	.85
Japan	.96	.96	-3.4	-4.0	.75	.80
Centrally planned economies:						
CMEA	.98	.88	-2.7	-3.7	.96	.95
China	1.09	1.23	.9	.5	1.02	1.01
Developing market economies:						
Argentina	1.01	1.18	1.1	2.4	1.30	1.49
Brazil	1.05	.90	1.5	-.3	1.17	1.02
Mexico	1.10	1.18	.3	.6	1.08	1.07
Egypt	1.12	1.15	-.1	-.2	.97	.96
Kenya	1.15	1.28	.2	.4	1.23	1.28
Nigeria	.95	.88	-.6	-2.9	.91	.82
India	1.11	1.02	.81	.1	1.03	1.00
Indonesia	1.06	.88	.1	1.1	1.02	.90
Pakistan	1.00	.92	-.2	-.2	.94	.97
Thailand	1.11	1.16	1.0	1.4	1.37	1.28
Turkey	1.14	1.28	.4	1.1	1.08	1.12

1/ Terms of trade in the indicated year relative to that in 1970.
2/ A positive number indicates surplus.
3/ Ratio of gross value of agricultural production to value of domestic demand for agricultural products.

Tariffs in the RO

Implicit in the price transmission equations that characterize government behavior in our models are the tariff factors that relate the domestic prices to the border prices. These factors thus reflect the extent to which the government protects or taxes domestic producers and consumers. Their evolution over time can be taken to reflect the evolution of government's protective policies over time and, thus, is an important attribute with which to characterize the nature of the RO. 4/

The calculation of the tariffs, which are actually tariff equivalents, requires a brief explanation (see also the discussion in the section on Notion of Trade

4/ For simplicity the word "protection" is used in this paper to also include negative measures.

Liberalization and Scheme of Analysis). In the case of imports, the border price is the c.i.f. (cost, insurance, and freight) price that is modified for differences in composition and quality between world market and domestic market. When the commodity is exported, the f.o.b. (free on board) price is taken, modified for the same differences as for imports, and the costs for all domestic export activities are subtracted.

The tariff equivalents, summarized for 1980 and 2000 in table 11, show that, in general, for most commodities and countries these factors remain more or less stable. Thus, the RO implies more or less a continuation of the historical levels of protection. The tariff equivalents for bovine and ovine meat, however, are somewhat an exception. They decline in some countries significantly and increase in Nigeria. The decline of tariff equivalents for bovine and ovine meat, when its world market price rises, implies that policies in countries protecting the sector are directed toward maintaining a desired level of domestic price for this product and not a certain level of protection. This may be a reasonable policy.

Some of the tariff equivalents suggest that the raw material price (for consumers or producers) differs widely for products that are substitutable. As a case in point, take the tariff equivalents for wheat and coarse grains in the EC in 2000, which are 112 percent and 37 percent, respectively. Since wheat is exported and coarse grains imported that year by the EC and due to the calculation procedure briefly outlined above, these equivalents are very different while the domestic producer price of wheat exceeds that of coarse grains by only 16 percent.

Maintenance and improvement of income parity are the objectives of various groups pressing for protective policies. Thus, parity is a relevant indicator of how well protective policies have worked in the scenario. The development of income parity between agriculture and nonagriculture is shown in table 12.

Here, income parity is defined as a ratio of GDP agriculture per agricultural labor to GDP nonagriculture per nonagricultural labor.

These income parity ratios may give somewhat biased results. This is because, in many countries, the data on labor employed in agriculture may include many part-time workers who work outside of agriculture. Their earnings from nonagricultural sector are not included with their agricultural income except for the model of India. Moreover, income from processing agricultural products is counted as a part of nonagricultural income in our models, which also, to the extent that such processing is done by many agricultural producers themselves, understates agricultural incomes. This discrepancy in the calculation of parity ratios does not affect the outcome of the models since, except for India, income classes are not distinguished in the models. Though the level of the income parity ratios as calculated may not be too reliable, the parity ratios are calculated consistently so their changes over time should be much more realistic.

The average annual growth rate of labor productivity over the period 1980-2000 varies substantially among countries and is the main source of difference in the growth rates of parity ratios. Growth of labor productivity in agriculture is affected by investment and by technical progress with the latter contributing a large share to the difference in the development of labor productivity among the countries.

Table 11--Nominal tariff equivalents of agricultural products, using consumer prices, 3-year average, 1980-82 and 1998-2000 1/

Country	Year	Wheat	Rice	Coarse grains	Bovine and ovine meat	Dairy products	Other animal products	Protein feed	Other food	Nonfood agriculture
					Percent of world market price					
Argentina	1980	-21	7	-20	-27	-17	-22	-0	-32	-5
	2000	-20	11	-11	-28	-18	-16	2	-28	-10
Australia	1980	15	27	29	-5	-7	40	15	14	-4
	2000	23	25	39	-10	-7	27	19	22	-4
Austria	1980	42	-5	85	74	34	11	20	10	46
	2000	38	-6	83	22	-12	4	22	9	81
Brazil	1980	13	2	-16	-13	22	-36	-11	-18	-19
	2000	33	-20	-27	-19	-11	-35	-10	-24	-19
Canada	1980	13	-7	14	25	53	-1	-18	-12	15
	2000	19	-8	21	6	23	-11	-18	-12	-7
Egypt	1980	30	-6	21	72	14	83	1	-23	-29
	2000	33	-23	19	41	11	83	-4	-23	-39
Indonesia	1980	-2	-12	-17	3	10	15	-4	-16	-36
	2000	-0	-12	3	-1	5	-2	-19	-25	-45
Japan	1980	35	253	42	52	106	43	134	44	98
	2000	31	254	39	56	69	27	127	37	74
Mexico	1980	-7	12	7	12	-3	22	-11	17	-33
	2000	-4	27	-7	-8	-14	17	-11	18	-28
Nigeria	1980	44	76	15	42	51	106	-18	-12	-16
	2000	47	131	37	82	145	115	-26	-11	12
Pakistan	1980	23	68	50	37	28	31	-2	-17	-17
	2000	16	44	82	1	31	22	4	-18	-30
Turkey	1980	31	44	20	61	249	63	55	6	-5
	2000	30	40	34	11	172	29	40	0	-1
EC	1980	84	65	42	61	70	26	35	5	26
	2000	112	61	37	12	34	24	36	12	28
Kenya	1980	10	0	0	-25	25	5	-5	-10	-10
	2000	10	0	0	-25	25	5	-5	-10	-10
New Zealand	1980	0	0	0	0	0	20	0	0	0
	2000	0	0	0	0	0	20	0	0	0
Thailand	1980	0	-20	-10	-25	30	-10	-10	-5	-25
	2000	0	-20	-10	-25	30	-10	-10	-5	-25
India	1980	68	2	9	9	48	3	1	-28	-9
	2000	54	-7	13	30	43	31	-30	-25	-13
United States	1980	0	0	0	25	80	-5	0	5	25
	2000	0	0	0	25	80	-5	0	5	25

1/ These are calculated as difference between border prices and domestic consumer raw material prices, taking into account transport distribution and processing differences and compositional deviations of the aggregates between the international and domestic market.

Though these various determinants of income parity ratios move differently, government policies in the price transmission equations adjust domestic prices and the protection rates in a way to produce income parity ratios that are, in general, consistent with past trends.

In a number of countries, income parity ratios improve over time in favor of agriculture, and yet even by 2000, agricultural incomes are less than nonagricultural incomes in all but four countries shown in table 12.

Table 12—Income parity ratios, productivity, protection, and price changes, selected years

Country	Income parity ratio 1/			Change per annum, 1980-2000		
	1961 2/	1980	2000	Parity	PA/ PNA 3/	Labor productivity 4/
				Percent		
North America and Oceania:						
United States	--	1.00	1.15	0.7	0.7	—
Canada	.50	.73	.80	.4	.1	.3
Australia	1.25	1.12	1.73	2.2	1.1	1.1
New Zealand	1.48	1.71	3.35	3.4	2.2	1.2
Other developed countries:						
Austria	.42	.41	.40	-.1	-.2	.1
EC	.47	.61	.71	.7	.2	.5
Japan	.26	.28	.30	.4	.1	.3
Centrally planned economies:						
CMEA	--	--	--	--	--	3.0
China	--	--	--	--	--	1.8
Developing market economies:						
Argentina	.67	.81	1.15	1.8	1.1	.7
Brazil	.16	.14	.13	-.2	.7	-.9
Mexico	.10	.12	.19	2.1	.4	1.7
Egypt	.25	.32	.27	-.8	.8	-1.5
Kenya	.08	.10	.14	2.0	.9	1.1
Nigeria	.53	.58	.59	.1	1.3	-1.2
India 5/	.54	.54	.56	.2	.5	2.3
Indonesia	.27	.38	.31	-1.0	.4	-1.3
Pakistan	.43	.46	.55	.9	.3	.6
Thailand	.08	.07	.04	-2.2	.4	-2.6
Turkey	.18	.29	.31	.4	-.3	.7

-- = Not calculated.

1/ (Agricultural gross domestic product (GDP)/agricultural labor)/(nonagricultural GDP/nonagricultural labor) at current prices.

2/ Based on Food and Agriculture Program (FAP) data base.

3/ PA = implicit GDP price deflator of agriculture. PNA = implicit GDP price deflator of nonagriculture.

4/ Defined as ratio of per labor GDP at constant prices in agriculture to that in nonagriculture.

5/ Parity figure for India to rural/urban rather than agricultural/nonagricultural per capita incomes.

Table 13 shows the share of agricultural GDP in total GDP and allocation of factors to agriculture. The share of agricultural GDP declines in all countries. Comparing the shares of labor and capital used in agriculture with the share of agricultural value added, one can see the relative factor intensity in agriculture. Thus, in 1980, the agricultural labor/capital ratio is higher in all the countries, except Australia and New Zealand, than the average ratio for the economy.

Welfare and Hunger in the RO

Some of the macroeconomic indicators of development and welfare in the various countries and country groups are shown in table 14. Not all the indicators are available or calculated for all the national models.

Comparison of per capita GDP valued at domestic 1970 prices and converted into U.S. dollars (US-$70) for different countries show that the absolute difference between the developed and the developing countries widens over the period 1980-2000. Thus, for example, the difference in the per capita GDP's between the United States and India increases from around $5,600 (US-$70) in 1980 to around $7,800 (US-$70) in 2000, even though the ratio of per capita GDP's declines over this period from 55 to 44.

The United States continues to remain the country with the highest (among the countries shown) per capita GDP, but Canada and Japan narrow the gaps to become the close second and third. Japan overtakes EC by far.

Equivalent incomes, shown in table 14, are calculated using 1970 domestic consumer prices as reference prices. Equivalent income constitutes a better measure than per capita GDP for comparing welfare of consumers in alternative situations. For the developed market economies, the growth rates of per capita GDP and equivalent income are more or less the same. This can be expected, since in high-income countries consumption expenditure on food is a relatively small part of the total consumption expenditure, food demand has relatively low price elasticity, and nonagriculture is just one aggregated commodity in our models. Therefore, changes in the composition of the consumption bundle due to changes in prices are not too significant. The income effect of changing prices may be significant, but it is also captured by the per capita GDP valued at 1970 prices.

For the developing countries, the growth rates of equivalent incomes are significantly different from the growth rates of per capita GDP. For some countries, growth rates of equivalent incomes are higher, and for other countries, the growth rates of per capita GDP are higher. This emphasizes the difficulties of using constant price per capita GDP for comparing alternative situations.

Per capita calorie intake (table 14) is an important indicator of welfare for developing countries. The table shows an improvement over 1980-2000 in all developing counties, and the minimum national average in the reference scenario for Indonesia is 2,374 Kcal per person per day.

Estimates of life expectancy at birth and number of people in hunger are derived using the results of the RO and cross-country regressions (3). These show significant improvement in all developing countries, except in Pakistan, which has a relatively high growth rate of population. Although the

Table 13--The position in 1980 and the development from 1980-2000 of agriculture in the economy

Country	GDP70 1/		GDPA70/GDP70 2/		TLA/TL 3/		AgCAP/Tot Cap 4/	
	1980	Growth 5/	1980	Growth 5/	1980	Growth 5/	1980	Growth 5/
	Billion U.S. dollars	Percent						
United States	12,548	2.7	2.3	-1.4	n.a.	n.a.	n.a.	n.a.
Canada	1,247	3.4	2.9	-1.4	4.5	-1.6	3.8	-1.4
Australia	537	2.6	7.4	-.7	5.6	-1.8	7.8	-.3
New Zealand	99	3.2	15.4	-1.2	9.5	-2.4	14.5	--
Austria	180	3.9	5.0	-2.7	11.3	-2.7	16.6	-2.1
EC	8,244	3.1	4.9	-2.4	8.4	-2.8	5.7	-1.2
Japan	3,554	5.4	3.7	-3.6	13.0	-3.6	6.5	-1.5
CMEA	9,772	4.4	14.6	-1.8	18.8	-4.2	15.1	2.0
China	2,648	5.2	14.3	-3.2	69.5	-2.3	20.7	-.1
Argentina	360	2.5	10.7	-.7	13.4	-1.2	12.3	-.6
Brazil	969	6.2	6.0	-3.2	38.2	-1.7	9.5	-2.9
Mexico	539	5.1	8.1	-1.3	46.4	-1.9	11.1	-.9
Egypt	107	4.7	21.0	-2.1	51.9	-.5	33.6	-1.1
Kenya	25	4.4	25.0	-.1	78.7	-.3	15.0	-1.1
Nigeria	156	7.0	33.4	-3.5	53.0	-1.9	15.5	-3.1
India	683	5.1	42.3	-2.6	n.a.	n.a.	n.a.	n.a.
Indonesia	125	5.2	35.9	-2.3	60.1	-.8	35.4	-2.2
Pakistan	145	4.0	28.3	-.6	52.7	-.8	28.6	.7
Thailand	98	5.3	19.8	-2.3	79.6	--	24.5	-1.4
Turkey	253	6.0	21.9	-3.0	52.3	-2.5	20.3	-4.1

n.a. = not calculated.
-- = Nearly zero.
1/ Total GDP at 1970 prices.
2/ Ratio of agricultural to total GDP, at 1970 prices.
3/ Ratio of agricultural to total labor force.
4/ Ratio of agricultural to total capital stock.
5/ Annual average growth rate from 1980-2000.

improvements in per capita GDP and calorie intake result in lower proportion of population in hunger, the number of persons in hunger increases over 1980-2000.

The estimates of hungry persons at the global level are given in table 15. Though incidence of hunger declines from 23 percent of population in 1980 to 11 percent of population of developing countries, excluding China, by 2000, there will still be 396 million people in hunger, a number only 20 percent below the 506 million shown in the scenario for 1980.

Results of Multilateral Trade Liberalization in Agriculture

This section contains results of a trade liberalization scenario. Before a detailed explanation of the result is given, some discussion of the concept of trade liberalization as used in this study is required.

Table 14--Country welfare indicators in the reference scenario, 1980 and 2000

Country	GDP/CAP 1/		Equivalent 2/ income		Nutritional intake		Life expectancy		People hungry	
	1980	2000	1980	2000	1980	2000	1980	2000	1980	2000
	1970 U.S. dollars/CAP		1970 U.S. dollars		Kcal/CAP		Years		Million	
United States	5,731	8,017	--	--	--	--	74	81	0	0
Canada	5,207	7,907	4,089	6,090	3,566	3,607	75	76	0	0
Australia	3,671	4,463	3,011	3,604	3,832	3,894	74	75	0	0
New Zealand	3,086	4,386	--	--	3,519	3,678	74	76	0	0
Austria	2,337	4,797	1,511	3,182	3,448	3,439	73	75	0	0
EC	3,120	5,212	2,455	4,024	3,491	3,604	75	77	0	0
Japan	3,080	7,554	1,682	4,252	2,749	3,029	76	81	0	0
CMEA	2,345	4,782	--	--	3,619	3,567	--	--	0	0
China	272	586	--	--	2,487	2,557	67	76	--	--
Argentina	1,350	1,795	905	1,233	3,653	3,656	71	72	1	1
Brazil	822	1,818	500	1,162	2,860	3,283	64	70	15	0
Mexico	798	1,157	553	799	2,487	2,588	66	71	6	6
Egypt	266	448	391	568	2,799	3,134	57	60	3	0
Kenya	166	200	--	--	2,495	2,802	56	59	5	7
Nigeria	181	390	193	319	2,254	3,168	49	59	26	2
India	104	181	72	88	2,141	2,533	52	58	201	187
Indonesia	83	151	17	40	1,840	2,374	54	61	46	15
Pakistan	182	224	107	132	2,460	2,718	50	53	21	25
Thailand	219	423	--	--	2,856	3,235	63	66	8	5
Turkey	580	1,231	274	701	3,137	3,219	61	67	3	3

-- = Not available.

1/ Calculated at domestic 1970 prices and converted into U.S. dollars.

2/ Equivalent income defined as income required to buy a consumption bundle with domestic consumer prices of 1970 that would provide the same utility as provided in current consumption.

Notion of Trade Liberalization and Scheme of Analysis

The analysis of trade liberalization in this study is restricted to removal of distortions between relative border prices and relative domestic prices at the level of raw materials. Not all distortion-creating measures from all markets and production activities are removed. Thus, the scenario moves toward free trade and not to total trade liberalization so one should characterize it as freer trade scenario. The reason for restricting the analysis to removal of only border protection measures is the difficulty of obtaining accurate information on all trade-distorting measures.

The analysis of trade liberalization is partial in still another way. The border protection measures of only agricultural goods are removed, as they are reflected in the estimates of tariff equivalents (table 11). Protection of nonagriculture is not touched because of unreliable information about its extent.

For some countries, additional changes are introduced. In the case of the United States, land set-aside programs are also removed in free trade as well as the import quotas for bovine and ovine meat and for dairy products. The wedges that exist between the consumer and producer prices for wheat, coarse grains, and bovine and ovine meat in Japan and for wheat in Nigeria are also set to zero. In Canada, the quota imposed on dairy production in the reference run is removed. The results for the EC must be interpreted with some caution because the monetary compensatory amounts (MCA's) are small in comparison with the EC's protection against third countries and one might argue that their impact on EC trade is not very drastic. This is especially so if one works with the hypothesis that the MCA's only distort the (absolute) price levels between the EC member countries but not the relative prices of agriculture.

It is assumed that China and the CMEA do not participate in trade liberalization, though they do modify their trade patterns in response to changing world prices.

When interpreting the results of a trade liberalization scenario, one has to be aware of some limitations of the analysis. The first is the uncertainty about the accuracy of the tariff equivalents. The tariff equivalents were calculated as differences between the domestic producer price and the corresponding border price. While the producer prices are taken directly from the FAO statistics, which are our data base, the world market prices are derived statistics (6). The world market price was taken to be the export price of the least cost major exporter, where major exporter is defined as one exporting at least 3 percent of the total world exports. The differences between prices of other exporters and the world market price are attributed to quality and composition differences (6). Some care should be exercised in interpreting the tariff equivalents. In cases where only tariffs, levies (fixed or variable), and customs duties are applied at the border, no difficulty arises. But, if production of the commodity under study is assisted in other ways, for example, through input subsidy, storage subsidy, and deficiency payment, the calculated tariff equivalents measure only border protections and not protection through these other means.

Thus, in our analysis of trade liberalization where these calculated tariff equivalents are removed, only the assistance given at the border is

Table 15--Global incidence of hunger, reference scenario, selected years

Item	Unit	1980	1990	2000
Population:				
World	Million	4,340	5,190	6,160
Developing countries 1/	do.	2,190	2,800	3,540
Hunger in developing countries: 1/				
Population	Percent	23	17	11
Persons	Million	506	473	396

1/ Excluding China.

abolished. The assistance given for domestic production of commodities is not affected by the removal of tariff equivalents. This holds for all types of assistance. We are aware of the limitations caused by a one-sided removal of protection but actually did not have the time and manpower to gather all the necessary information on the level and incidence of domestic assistance.

Considerable effort has been made to account for transport, distribution, and processing differentials in deriving export and import prices for the country so they are not treated as tariff equivalents. Also, quality and commodity composition differentials have been taken into account in aggregating commodities. The results have been checked against and estimated from other sources, whenever available. Nevertheless, the figures are subject to uncertainty, particularly for the country groupings, for which approximations have had to be made. In treating all nontariff barriers as tariff equivalents, the incidence of the protection measure is distorted, for example, an import quota increases the domestic price and the rent from this quota goes to the importer whereas the government gets the receipts from a tariff. Since trade quotas are explicitly introduced in the model of the United States, they do not lead to distortions in this country.

A possibility that should be recognized in analyzing the impact of a partial liberalization, as it is studied here, is that removing some trade distortions while leaving others in place (nonborder measures and protection of nonagriculture) might exacerbate the distorting effects of the latter.

Another limitation arises from the modeling of price responses for the country groupings of both demand and supply. Whereas the models and their implied price responses for individual countries, as well as the EC, are likely to be as realistic as any models, due to lack of data, the price response in the models of country groupings is ad hoc. If the planned economies are excluded, which in practice are unlikely to participate in trade liberalization, the share of world agricultural output accounted for in models with not so reliable a price response is of the order of 20-30 percent.

These limitations call for prudence in interpreting the results of a trade liberalization scenario. Figures should be considered as approximate rather than precise estimates and as indicating general directions of movement. The apparent precision in the tables is unavoidably higher than the results warrant, as is the case in any economic modeling exercise.

In the scenario, the transition to trade liberalization is assumed to take place over a 5-year period, from 1982-86. Since a number of time lags are built into the various models of the BLS, several years of adjustment may be required to fully capture the impact of trade liberalization.

Results of the Trade Liberalization Scenario

Although some tables in this section include information on the simulated impact of trade liberalization in 2000, the discussion focuses on results obtained for 1990. This is done at the request of the organizers of the meeting who asked for an analysis of trade liberalization over a 5-year period. As will be seen, this is too short a period to get the adjustments fully done in those countries that face drastic price changes. Additional 5 or even 10 years are needed so that agriculture reaches another steady-state situation.

Trade Liberalization Leads to Higher Agricultural Prices at the World Market. The average agricultural price increase at the world market is about 9 percent when the countries liberalize agricultural trade (table 16). A strong divergency, however, is among the commodities with regard to price changes. In general, the products of which the OECD countries are net exporters in the reference scenario increase in price, while the others decrease. The only exception to this rule is bovine and ovine meat. The OECD countries as a group are net importers of this commodity. Grain prices go up by about 15-20 percent with rice showing the strongest upward move. Protein feed increases by about 11 percent. The largest price increase occurs for dairy products (nearly 40 percent). This is not surprising because international trade in dairy products is highly distorted; especially by the EC, which holds an export share of 45 percent and a production share of 20 percent in 1990 in the RO. The price of bovine and ovine meat goes up by 25 percent, which is the second largest increase. This result is affected to some extent by the removal of dairy protection in those countries where dual purpose cattle are dominant.

The two products showing only marginal price changes are other animal products with an upward change and other food with a downward change. The only commodity indicating a strong decline of its world market prices is nonfood agriculture. This commodity is negatively protected by many developing countries, which as a group have an export share of 38 percent and a production share of over 50 percent in the RO in 1990.

No Significant Global Production Changes. The changes in prices at the world market do not translate into substantial production increases (table 16). Two percent is the largest increase that can be observed for bovine and ovine meat and for protein feed. Also, the nonagricultural aggregate is not produced at

Table 16--Changes in prices, production, and net trade between reference run and trade liberalization run at world market level, 1990 and 2000

Item	Prices		Production		Net exports	
	1990	2000	1990	2000	1990	2000
			Percent			
Wheat	16	23	1.4	1.1	1	3
Rice	22	16	1.3	1.6	35	36
Coarse grain	17	13	.7	1.7	-4	-3
Bovine and ovine meat	26	11	2.2	5.3	52	69
Dairy products	38	34	1.2	2.4	30	24
Other animal products	3	-1	.7	1.0	3	14
Protein feed	11	13	2.7	2.3	5	4
Other food	-1	-3	.2	0	4	10
Nonfood agriculture	-11	-17	-.1	-1.1	5	6
Nonagriculture	--	--	0	0	13	13
Total agriculture	9	5	.8	1.1	--	--

-- = Approximately zero.

a higher level. However, similar results are also obtained in other studies on trade liberalization using a general equilibrium approach. 5/

One explanation for this outcome might be that agriculture is only a small part of the economy in most countries and the nonagricultural sector does not capture possible improvements through reallocating factor inputs. Another explanation could be a certain lack of flexibility in the reallocation of factors. The functions used in the BLS to allocate labor and investment between agriculture and nonagriculture do not work entirely according to the neoclassical principle. In addition, within agriculture, the factor allocation is not completely flexible. Finally, it is sometimes argued that the resources broadly engaged in activities related to protection (for example, customs and lobbying) are not shifted back into productive engagements.

Trade Volume and Structure Change Considerably. Although production does not respond to those higher agricultural prices, international trade does. Trade of bovine and ovine meat increases relatively strongest, by 52 percent or 2.1 MMT in 1990, compared with the RO (table 17). Of this additional volume traded, the EC imports 34 percent (or 0.7 MMT) more and the United States 26 percent (or 0.6 MMT), both together 60 percent. These additional 2.1 MMT are mainly sold on the world market by Argentina (67 percent) and Australia and New Zealand (each 10 percent).

The volume of dairy products traded increases by 30 percent or 6.3 MMT. This amount is exported by Canada alone after removing the milk production quota leading to the zero trade position in the reference run. But, also Australia, Argentina, and New Zealand increase their exports, while the EC reduces its exports by 2.2 MMT and the United States by 2.3 MMT. The United States even becomes a sizable importer. Altogether, strong shifts are seen in the export market shares for dairy products; the main losers being the United States and EC with a reduction of 100 and 23 percent, respectively. Canada increases its export share from zero to 22 percent and Argentina from zero to 3 percent. Altogether it might be argued that among all agricultural commodities dairy products adjust strongest in international trade. This is especially so, if one also considers that three developing countries switch from an importing to an exporting position (India, Kenya, and Mexico) and another one into the opposite direction (Turkey).

Another product with a considerable expansion of global trade is rice. Its trade volume goes up by 30 percent. But only a few countries show a considerable change in their trade structure. Japan increases its rice imports drastically; approximately by a factor of 15 reaching a total of more than 8 MMT. According to the model results, Japan buys half of the total quantity of rice traded in 1990, if there is multilateral trade liberalization. Sixty percent of Japan's additional demand is met by more exports, mainly from Thailand. But some other countries cannot or do not have the need to maintain the import level they hold in the reference run, especially Indonesia which curtails imports by 2 MMT or 80 percent. Hence, for the remaining 40 percent, Japan replaces some other countries as an importer.

5/ For example, G.W. Harrison, A General Equilibrium Analysis of Tariff Reductions, Working paper No. 8406C, Department of Economics, The University of Western Ontario, London, Canada (1984).

Table 17--Changes in trade structure worldwide and in selected countries due to a multilateral liberalization of agricultural trade, 1990

	Unit	World	EC	Argentina	Australia	Canada	Japan	New Zealand	United States
Wheat:									
Trade change	Percent	1	-80	3	14	-7	1	-59	29
Export volume change	1/	.8	-16.1	.2	1.9	-1.3	--	--	14.9
Import volume change	1/	--	--	--	--	--	.1	-0	--
Rice:									
Trade change	Percent	35	85	58	-14	-4	1,450	1	5
Export volume change	1/	4.5	--	+0	-0	--	--	--	.2
Import volume change	1/	--	.2	--	--	-0	7.7	+0	--
Coarse grains:									
Trade change	Percent	-4	-43	-10	-20	-64	1	30	4
Export volume change	1/	-5.0	--	-1.1	-1.3	-5.6	--	.1	3.0
Import volume change	1/	--	-5.4	--	--	--	.2	--	--
Bovine and ovine meat:									
Trade change	Percent	52	140	163	33	84	16	22	42
Export volume change	1/	2.1	--	1.4	.2	.1	--	.2	--
Import volume change	1/	--	.7	--	--	--	.1	--	.6
Dairy products:									
Trade change	Percent	30	-23	--	114	2/ --	-26	15	--
Export volume change	3/	6.3	-2.2	4/ .8	1.9	6	--	.7	-2.3
Import volume change	3/	--	--	-0	--	--	-.2	--	3.2
Other animal products:									
Trade change	Percent	3	--	1,955	--	4	50	-97	53
Export volume change	5/	.04	-.08	.02	-.01	.01	.09	-.01	.10
Import volume change	5/	--	.02	--	+0	--	--	--	--
Protein feed:									
Trade change	Percent	5	-6	-13	44	-58	54	49	-1
Export volume change	5/	1.0	--	-0	.1	--	--	+0	.1
Import volume change	5/	--	-.3	--	--	-.2	1.6	--	--
Other food:									
Trade change	Percent	4	20	294	-36	-17	50	117	-12
Export volume change	6/	.9	--	.6	-.2	--	--	--	-.4
Import volume change	6/	--	1.2	--	--	-.1	.9	+0	--
Nonfood agriculture:									
Trade change	Percent	5	15	35	4	-8	4	8	3,726
Export volume change	6/	.3	--	.1	0	-0	--	0	--
Import volume change	6/	--	.3	--	--	--	.1	--	0
Nonagriculture:									
Trade change	Percent	13	26	137	21	53	30	33	20
Export volume change	6/	6.2	2.7	--	--	--	2.2	--	--
Import volume change	6/	--	--	2	.45	.7	--	.4	1.4

-- = Approximately zero; +0 and -0 indicate very small changes.
1/ Volume in million metric tons.
2/ Base value zero.
3/ Volume in million metric ton of milk.
4/ Argentina changes from being a minor importer to being an exporter of dairy products.
5/ Volume in million metric tons of protein.
6/ Volume in billion 1970 U.S. dollars.

Although the other commodities are not traded at substantially different levels at the world market, some significant changes are still to be found in the trade structure. The EC loses most of its export share of wheat (80 percent), which is almost entirely taken up by the United States. But also Australia is able to boost its wheat export by 14 percent (or 2 MMT), while Canada cuts back the export of both wheat (7 percent) and coarse grains (65 percent). Coarse grain exports are also reduced by Australia (20 percent) and Argentina (10 percent) and expanded by the United States (4 percent). The United States can somewhat increase its market share in coarse grain exports from 73 percent in the reference run to almost 80 percent under trade liberalization. Among the coarse grain importing countries only the EC cuts its imports by a sizable amount (43 percent).

Three countries cease to export other animal products (Australia, EC, and New Zealand). The EC becomes an importer of this product, while the other two countries more or less stop trading internationally. Relatively large changes occur also in Japan and the United States with both expanding their exports of this aggregate. Under the current scenario, Japan holds a share of the total world market of 25 percent and the United States of 36 percent. Argentina reaches 4 percent but has practically no exports in the RO. Seventy percent of the additional exports are imported by developing countries, thereby increasing their import share from 15 to 17 percent.

Adjustments in protein feed trade are mainly occuring in Australia (4 percent more export), others are in Japan (50 percent more import) and Brazil (18 percent more export). Most (70 percent) of the aggregate other food is exported by developing countries in the reference run. Under trade liberalization, this share increases to about 80 percent mainly because of a reduction in exports by the United States. For nonfood agriculture, a similar shift can be observed, however, at much lower levels. The developing countries increase their export share from 37-42 percent.

The changes in the agricultural trade balance are also quite substantial (table 18). The developing countries, in general, improve their agricultural trade balance with the exception of Pakistan (increase in deficit) and Turkey (reduction in surplus). Among the developed market economies, the EC and Japan show a deterioration of their agricultural trade deficit, all others an improvement of either their surplus or deficit. A similar observation can be made if one looks at the changes in the volumes of trade in nonagriculture (table 17). Since in most countries the value of the overall trade balance does not alter very strongly between the multilateral trade liberalization and the RO, any change in the agricultural trade balance must be compensated by trading in the nonagricultural commodity. 6/

In the following paragraphs, the adjustments at the country level are described for a few selected countries.

Strong Price Increases in Argentina. Argentina shows a very strong increase in domestic prices (table 19). A shift of labor into agriculture and higher agricultural investment is the result. But also more land is cultivated, and more fertilizer is used. GDP of agriculture increases by 20 percent giving an

6/ Trade in the nonagricultural aggregate is not calculated as a residual in the model. The volume of trade is simultaneously determined for all commodities.

Table 18--Changes in the agricultural balance of trade under multilateral trade liberalization, 1990

Country	Change	Country	Change
	Percent		Percent
EC	43 D 1/	Egypt	-268 D
Austria	-36 D	Kenya	-8 S
Australia	18 S 2/	Nigeria	3 D
Canada	37 S	India	78 S
Japan	50 D	Indonesia	-55 D
New Zealand	35 S	Pakistan	21 D
United States	11 S	Thailand	16 S
Argentina	112 S	Turkey	-20 S
Brazil	101 S	Mexico	25 S
CMEA	6 D	China	-3 S

1/ D = Deficit in the reference scenario.
2/ S = Surplus in the reference scenario.

implicit supply elasticity of about 0.35. Especially for Argentina, it becomes clear that the adjustment in agriculture is not completed 5 years after the total removal of tariff equivalents. A look at the results for 2000 reveals that still quite some changes occur. More labor is employed in agriculture, and more fertilizer and capital are used so GDP agriculture increases even further, although the agricultural price index falls again slightly. The implicit supply elasticity increases to unity by 2000.

Table 20 shows the adjustments taking place for each commodity. The producer price of bovine and ovine meat increases most. But that of wheat and coarse grains rises also substantially pushing up feed cost. Since protein feed becomes cheaper relative to the grains, its share in the feed rations is increased. Production of all three animal types is enlarged by 15-25 percent.

A substantial shift in the crop production pattern occurs in Argentina. Two facts are causing it. First, the higher marginal productivity of fertilizer in the nongrain crops leads to a stronger increase in fertilizer application and, hence, yield for those crops. Second, the land shadow price goes up considerably, thereby, favoring those crops with a relatively high net revenue per hectare. As a result, acreage of coarse grains is reduced and, instead, planted with crops of the aggregates other food and protein feed. Wheat acreage remains virtually unchanged. The additional acreage cultivated (11 percent) is entirely used for roughage production.

Trade in grains changes relatively little. Thirty percent of the increase in wheat production is used as additional feed, while for coarse grains the rise in output matches only 30 percent of the larger feed use.

With the exception of wheat, human consumption of all agricultural products declines as a result of the rather high increase of their retail prices. The food price index goes up by 30 percent. Where applicable, changes in total disappearance of agricultural goods are dominated by increases in feed use.

Table 19--Changes of some indicators between multilateral trade liberalization and reference scenario, 1990 and 2000

Item	Argentina		Australia		Austria		Brazil		Canada		China		Egypt	
	1990	2000	1990	2000	1990	2000	1990	2000	1990	2000	1990	2000	1990	2000
	Percent													
GDP 1/	0.3	-0.2	0.2	0.1	0.2	0.1	-0.4	-0.8	0.1	-0.1	0	0	-0.7	-2.6
Investment	8.9	9.8	1.5	.7	.2	.4	1.5	.5	.4	.4	0	0	.8	-1.6
Agr. GDP 2/	19.6	47.0	1.6	1.3	-1.5	.4	4.8	7.1	7.7	16.7	0	0	3.3	4.8
Agr. volume index 3/	18.9	42.8	2.1	1.3	-1.2	1.1	7.4	12.0	5.4	13.9	0	0	9.9	15.0
Calories produced	3.7	-29.6	4.8	-7.2	-13.6	-17.5	8.7	16.9	-10.5	-13.0	0	0	10.9	8.7
Agr. capital stock	29.7	77.3	8.3	10.2	-.9	1.5	22.3	33.4	8.6	20.0	0	0	5.0	11.2
Agr. labor force	17.1	48.9	1.3	3.6	-2.2	.5	.8	2.4	6.1	18.8	0	0	2.3	4.5
Total acreage	11.1	1.2	-.4	0	0	-0	7.5	12.1	3.3	2.3	0	0	.4	3.2
Nitrogen fertilizer	59.3	137.8	38.1	19.1	-7.5	-3.7	6.1	10.6	1.3	28.2	0	0	18.8	30.6
PA/PNA 4/	55.5	47.6	17.5	8.5	-.1	5.9	28.4	25.0	10.0	12.8	0	0	9.3	8.1
Crop price index	37.7	41.1	-7.3	-10.3	-12.9	-11.8	17.5	15.2	7.4	7.5	0	0	20.9	19.3
Food price index	30.7	22.8	16.8	8.6	-2.1	-.9	15.0	16.9	5.2	4.2	0	0	-3.1	-3.8
Terms of trade	19.3	19.4	13.4	14.6	37.8	66.7	4.6	3.3	21.7	29.2	-1.3	-10.7	-8.8	-9.6
Agr. self-reliance 5/	18.8	33.2	0.4	-1.7	-2.0	.2	7.1	12.0	-.8	1.0	0	0	10.7	16.6
Parity ratio	58.2	44.9	17.6	5.8	.5	5.6	33.9	31.0	11.5	10.6	0	0	9.6	8.1
Equivalent income	.5	3.2	-.6	-.1	.6	.3	-.8	-1.4	0	-.0	0	0	-.1	-2.1
Calories per capita	-2.2	-1.5	.4	.7	.5	.5	-1.8	-2.0	-.5	-.8	0	0	.3	-.4
Protein per capita	-3.1	-2.3	.3	.7	.5	.5	-2.5	-2.1	-.8	-1.4	0	0	1.2	.6
People hungry 6/	-1.0	-30.9	--	--	--	--	21.7	49.8	0	--	--	--	0	0

Item	India		Indonesia		Japan		Kenya		Mexico		New Zealand		Nigeria	
	1990	2000	1990	2000	1990	2000	1990	2000	1990	2000	1990	2000	1990	2000
	Percent													
GDP 1/	0.2	0	0.4	1.1	0.2	0.3	1.7	3.2	-1.6	-4.1	1.3	1.3	0.4	-0.6
Investment	-.4	.1	8.2	5.5	-.9	-.4	8.4	8.5	-1.1	-4.4	6.2	3.5	.9	-1.8
Agr. GDP 2/	.4	-.1	2.7	6.1	-5.8	-5.6	5.5	10.0	.9	1.4	9.8	10.8	2.6	-1.3
Agr. volume index 3/	.1	-0	3.1	7.1	1.1	.5	1.1	7.6	.6	2.2	7.4	9.9	2.9	.1
Calories produced	0	-0	2.5	5.5	310.5	128.2	-2.5	6.0	19.6	29.7	10.9	21.0	2.9	-.8
Agr. capital stock	0	0	8.0	19.8	-13.5	-24.1	9.5	19.4	.6	-.9	16.0	23.9	2.2	-3.6
Agr. labor force	0	0	1.1	1.1	-3.8	-5.4	0	0	4.5	11.9	1.0	2.2	2.3	-1.1
Total acreage	0	0	-0	-0	-11.6	-6.0	0	0	-0	-2.0	0	0	.5	-6.0
Nitrogen fertilizer	.6	.5	5.9	16.8	-33.9	-47.2	-8.0	2.1	.6	3.6	-8.3	-2.5	.9	.7
PA/PNA 4/	6.4	3.3	20.6	17.1	-39.4	-38.5	20.5	15.2	.4	-4.7	19.3	8.4	-4.0	-8.6
Crop price index	0	0	24.3	19.5	-45.4	-46.0	8.6	5.3	1.8	-3.8	2.6	-.1	4.4	2.5
Food price index	0	0	10.6	8.3	-19.6	-20.5	19.0	15.0	-1.4	-3.6	12.4	9.6	-5.4	-8.2
Terms of trade	4.0	12.2	-12.0	4.4	-5.4	-5.8	-1.2	-2.9	4.5	2.7	19.9	11.7	-10.1	-8.8
Agr. self-reliance 5/	1.9	1.6	4.6	6.0	-8.3	-9.6	-1.6	4.6	1.6	3.3	5.4	7.1	2.5	-.3
Parity ratio	3.7	1.4	21.4	22.0	-40.7	-38.7	26.4	25.5	-4.0	-14.8	29.7	17.4	-5.2	-7.9
Equivalent income	-.3	.6	-2.5	-.4	1.3	1.3	--	--	1.8	-4.0	--	--	.7	.3
Calories per capita	-.1	-.4	-1.0	1.8	4.2	3.9	2.6	3.1	0	.2	.7	.8	1.1	1.1
Protein per capita	.8	.9	-1.6	2.1	3.6	3.8	3.2	3.3	-.6	-.5	.7	.8	1.2	2.2
People hungry 6/	.4	2.2	17.3	0	--	--	10.9	-14.2	-.5	-2.8	--	--	-8.8	-56.9

See footnotes at end of table.

Continued--

Table 19--Changes of some indicators between multilateral trade liberalization and reference scenario, 1990 and 2000--Continued

Item	Pakistan		Thailand		Turkey		USA		CMEA		EC	
	1990	2000	1990	2000	1990	2000	1990	2000	1990	2000	1990	2000
						Percent						
GDP 1/	1.8	3.1	0.1	0.1	0.6	1.2	0.1	0.1	-0.0	-0.3	0.1	0.2
Investment	1.7	2.9	4.8	3.1	-1.6	.3	0	0	-.2	-1.0	-.3	-.1
Agr. GDP 2/	-.6	-.9	2.5	5.7	-3.3	-8.9	1.4	1.4	-0	-.5	-3.5	-7.5
Agr. volume index 3/	2.6	3.0	2.3	6.3	-2.8	-8.4	1.6	1.5	0	-.3	-4.8	-8.6
Calories produced	4.8	7.3	10.8	15.3	6.9	6.6	6.7	12.4	-.2	-2.6	-13.8	-7.8
Agr. capital stock	-2.8	-2.8	8.2	17.8	-7.0	-13.8	0	0	-0	.1	-2.1	-5.5
Agr. labor force	-.3	-3.2	0	0	-3.1	-7.9	0	0	0	0	-6.0	-12.1
Total acreage	-.6	-1.2	0	0	-.4	-1.0	2.9	2.5	0	0	-1.8	-2.2
Nitrogen fertilizer	22.7	11.1	2.2	6.6	.1	-6.2	0	0	1.9	6.2	-15.3	-15.5
PA/PNA 4/	-.5	-1.3	25.4	19.8	-15.0	-10.3	1.4	-4.6	0	0	-12.7	-11.9
Crop price index	6.0	8.9	23.5	19.2	-8.6	-6.8	0	0	0	0	-16.5	-18.7
Food price index	-1.0	-1.0	10.9	8.1	-6.3	-3.0	.4	-3.8	0	0	-5.3	-5.4
Terms of trade	9.8	8.2	3.3	.5	-6.4	-8.5	5.8	1.2	-3.4	1.2	-1.6	-1.0
Agr. self-reliance 5/	2.6	1.8	3.7	7.4	-1.2	-6.3	.8	-.3	-.1	-1.3	-6.4	-9.1
Parity ratio	-2.9	-.5	28.9	27.4	-14.6	-10.4	--	--	0	0	-10.2	-7.2
Equivalent income	2.0	2.7	--	--	1.7	2.1	0	0	0	0	.4	.4
Calories per capita	.2	1.4	-.2	-.3	0	.2	0	0	0	.2	1.0	1.0
Protein per capita	.4	1.6	-.7	-.7	.1	.2	0	0	0.1	.4	1.2	.9
People hungry 6/	-1.6	-16.9	1.6	3.3	-.5	-5.7	--	--	--	--	--	--

-- = Not calculated.
1/ Gross domestic product at 1970 prices.
2/ Agricultural gross domestic product at 1970 prices.
3/ 1970 prices used as weights.
4/ Agricultural price index relative to the nonagricultural price.
5/ Value of output to value of demand.
6/ Number of people hungry is estimated only for developed countries and also not for China.

As for most countries with a surplus in agricultural trade, the terms of trade for Argentina increase. The welfare indicators show that Argentina is not better off in every aspect. Equivalent income increases, but, due to higher food prices, nutritional intake falls. As a result, the number of people hungry increases by 50 percent in 1990.

Australia Expands Mainly Wheat and Milk Production. The agricultural price index increases in Australia by 18 percent in 1990 under multilateral trade liberalization (table 19). But this is almost entirely due to a price rise of ruminant products; exports of both commodities are taxed in 1990 in the reference run (bovine and ovine meat 11 percent and dairy products 12 percent). The majority of agricultural prices, however, falls, especially that of other food, other animal products, and coarse grains (table 21). With regard to coarse grains, it is interesting that the gap between wheat and coarse grain prices widens. This leads to the change in the structure of grain production. Wheat production is increased at the expense of coarse grains. 7/ Since feed use of grains also goes down, the change in net export of coarse grains is not as pronounced as it might be otherwise.

Grains and protein feed are used less for feeding purposes because of the decline in other animal production, which, in turn, is triggered by its price fall. The increase in net export of protein feed is mainly a result of the lowered feed use.

As shown in table 19, Australia's equivalent income goes down but a cost of consumption comparison (not shown in that table) indicates that it is better off.

Milk Production Increase Dominates All Production Changes in Canada. As mentioned earlier, the production quota imposed on Canadian dairy farmers in the reference run is taken away in this scenario. 8/ This is the main reason why milk production goes up in Canada by 75 percent in spite of a relative and absolute fall of the dairy price (table 22). Ninety percent of the additional production goes into export giving Canada a world market share of 22 percent, the highest of all dairy products exporting countries. The additional production of bovine and ovine meat comes entirely from a higher number of dairy cattle slaughtered and not from an increase in beef cattle fattening. The dairy cattle herd increases by 80 percent or 12 percent annually over 5 years.

The differences in the price response of wheat and coarse grains production requires an explanation. Judging from the domestic price structure, coarse grains production should be expanded instead of wheat but not contracted as it happens. The explanation for this result is that wheat yield is more price responsive relative to that of coarse grains. Hence, the profitability of wheat rises more than that of coarse grains, leading to a substitution in acreage between these two grains. The reduction in production together with the increase in feed use leads to this drastic cut (65 percent) in coarse grain exports.

7/ The cross-price elasticities of supply of these two commodities are -1.1 for coarse grains with regard to wheat price and -0.5 for wheat with regard to coarse grains price.

8/ The production quota on milk is set in the reference at a level that matches expected demand and gets a shadow price of approximately 50 percent of the milk price.

Table 20--Production, net export disappearances, and prices in 1990: Values in reference scenario and changes to multilateral trade liberalization for Argentina

Commodity	Reference scenario 1/			Change over reference scenario					
	Production	Net exports	Feed	Production	Demand	Net exports 2/	Feed	Retail prices	Producer prices
				Percent					
Wheat	9.94	5.30	0.76	3.5	3.4	2.5	13.8	12.0	49.6
Rice	.25	.02	.03	7.3	3.1	57.8	23.0	2.1	4.9
Coarse grains	20.59	11.00	7.96	2.4	16.2	-10.0	19.3	53.3	49.5
Bovine and ovine meat	4.45	.87	0	27.1	-6.1	163.1	0	53.8	75.5
Dairy products	5.61	-.05	0.15	15.1	.3	3/	22.8	10.9	26.9
Other animal products	.14	0	0	20.7	-4.9	1,955.0	0	16.0	23.7
Protein feed	.47	.19	.24	20.4	41.3	-13.0	44.5	18.2	18.2
Other food	2.45	.20	.02	24.7	.8	294.3	31.2	12.6	36.7
Nonfood agriculture	.71	.34	0	17.1	-.1	35.0	0	-2.6	-2.6
Nonagriculture	44.98	-1.45	0	0	4.3	137.5	0	--	--

-- = Approximately zero.

1/ See table 1 for units of measurement.

2/ A number smaller than -100 indicates a switch in trading position. The change is calculated as trade value, in current scenario divided by that in reference run minus unity and expressed as percentage.

3/ Argentina's dairy product exports in 1990 are 0.78 million metric tons under trade liberalization.

Table 21--Production, net export disappearances, and prices in 1990: Values in reference scenario and changes to multilateral trade liberalization for Australia

Commodity	Reference scenario 1/			Change over reference scenario					
	Production	Net exports	Feed	Production	Demand	Net exports 2/	Feed	Retail prices	Producer prices
				Percent					
Wheat	17.50	12.97	1.71	13.7	-1.8	14.4	-15.1	0.2	0.6
Rice	.36	.24	.06	-11.0	-6.0	-13.9	-10.9	-5.2	-5.8
Coarse grains	10.83	6.65	3.04	-13.0	-3.3	-19.7	-1.6	-6.3	-8.4
Bovine and ovine meat	2.97	.52	0.00	4.2	-2.0	33.3	-15.4	42.0	42.1
Dairy products	8.97	1.69	1.03	23.7	2.5	114.7	3.7	27.3	61.0
Other animal products	.12	.01	0	-14.0	3.0	-168.9	0	-6.6	-9.8
Protein feed	.41	.12	.29	2.3	-14.4	43.7	-14.6	.8	.8
Other food	1.43	.44	.02	-10.4	1.0	-36.1	25.6	-6.6	-16.4
Nonfood agriculture	1.06	.70	0	3.4	1.1	4.4	0	-3.5	-3.4
Nonagriculture	67.10	-2.15	0	0	.7	20.8	0	--	--

-- = Approximately zero.

1/ See table 1 for units of measurement.

2/ A number smaller than -100 indicates a switch in trading position. The change is calculated as trade value, in current scenario divided by that in reference run minus unity and expressed as percentage.

Table 22--Production, net export disappearances, and prices in 1990: Values in reference scenario and changes to multilateral trade liberalization for Canada

Commodity	Reference scenario 1/			Change over reference scenario					
	Production	Net exports	Feed	Production	Demand	Net exports 2/	Feed	Retail prices	Producer prices
				Percent					
Wheat	25.22	19.09	2.57	0.4	6.2	-6.7	14.4	1.3	5.7
Rice	0	-.11	0	0	-4.1	-4.1	0	11.0	22.6
Coarse grains	29.67	8.77	17.96	-9.0	12.9	-63.8	15.5	8.5	7.4
Bovine and ovine meat	1.55	.14	0	3.7	-4.2	83.5	0	10.4	10.0
Dairy products	8.53	.01	.81	76.2	5.1	3/	27.0	-2.0	-3.9
Other animal products	.47	.18	.	.5	-2.1	4.4	0	8.0	12.3
Protein feed	.98	-.35	1.24	9.1	-10.0	-58.2	-10.4	31.0	31.0
Other food	1.38	-.37	.06	4.5	-.1	-17.2	9.2	3.3	7.3
Nonfood agriculture	.33	.14	0	-2.5	1.5	-8.5	0	-10.8	-10.8
Nonagriculture	176.62	-1.33	0	-.1	.3	53.5	0	--	--

-- = Approximately zero.

1/ See table 1 for units of measurement.

2/ A number smaller than -100 indicates a switch in trading position. The change is calculated as trade value, in current scenario divided by that in reference run minus unity and expressed as percentage.

3/ Canada's dairy product exports in 1990 are 6.01 million metric tons under trade liberalization.

The opposite can be observed for protein feed. The producer price of this aggregate increases most (30 percent) among all agricultural commodities, leading to a 10-percent increase in output. At the same time, protein feedbecomes less profitable to be used in the feed rations and is substituted by grains. Together, this results in the reduction of protein feed imports of about 60 percent.

If one looks at the agricultural sector as a whole, one finds that the labor force and the capital stock are increased by 6 and 8 percent, respectively (table 19). This is an outcome of the improvement of the domestic terms of trade. Agricultural prices rise by 10 percent as an aggregate, while agricultural GDP goes up by 7.7 percent, resulting in an implicit supply elasticity of approximately 0.8. In 2000, this elasticity reaches a value above unity. It should be noted that acreage expands stronger than fertilizer use, which implies a decline in the average fertilizer application rate. This might be surprising if one compares the rise of fertilizer use with the crop price index that increases by 17 percent. But much area goes into roughage production with little fertilizer use.

Canada's terms of trade improve considerably, however, with only a small impact on welfare. Equivalent income shows a marginal increase.

Japan Increases Production of Milk, Pork, Poultry, and Eggs. Faced with a price drop in the aggregate of nearly 40 percent, Japanese farmers reduce investment and seek employment in other sectors of the economy (table 19). The agricultural labor force goes down by 4 percent in 1990 under multilateral trade liberalization, compared with the reference run. This outmigration is rather modest, if one considers that the parity ratio falls by 40 percent. Land is left idle, and fertilizer use is cut back substantially.

Production of all commodities except milk and other animal products goes down (table 23). Other animal products increase 10 percent, which translates into an increase of pork, poultry, and egg production of 26 percent, since fish production is not changed between these two scenarios. 9/ This rather strong increase is mainly a result of changing feed costs, which decline so strongly that the net revenue per animal even goes up. Since demand increases much less, Japan is able to expand its export of this aggregate by 50 percent and reaches a share of the world market of almost 25 percent in 1990 under multilateral trade liberalization. Although the reduction in feed costs cannot completely offset the fall in the milk price, an increase in yield per dairy cattle leads to a relatively small decrease in net revenue so that the competitiveness of dairy cattle is improved. The higher output of both milk and pork, poultry, eggs, and a (relatively little) substitution for grains in the feed rations leads to higher feed use and imports of protein feed.

Another drastic change in Japan is the reduction of rice production. But, this is easily explained by the substantial fall of the rice price. Production is cut back by 3 percent, and demand is increased by the same percentage. This lowers the self-sufficiency rate from 95 percent in the reference run to 40 percent in this scenario. The increase in total demand is almost entirely due to an increase in feed use. This means that Japan will import rice bran as the only component of rice which is fed.

9/ The aggregate other animal products contains approximately 60 percent fish in 1990 in the reference run. The rest is pork, poultry, and eggs.

Japan's welfare improves. The equivalent income increases by 1 percent. The substantially lower food prices also lead to an increased nutrient intake (table 19).

New Zealand's Share of the World Dairy Market Decreases. The strong increase of the domestic milk price (38 percent) in New Zealand leads to a rise in milk production of 10 percent (table 24). A further increase in production is hampered by a lack of labor. Employment in agriculture does not go up in spite of an improvement of the parity ratio by 40 percent.

Bovine and ovine meat production increases at the same rate as that of milk, and other animal products are cut back in output due to the price decline. Decline of the latter causes the use of all feed items to go down at almost the same rate as the output of other animal products. In turn, the changes in feed use determine largely the adjustments in trade of grains because human consumption reacts only marginally to the changes in retail prices and income. The self-reliance of agriculture increases further, which reached already the highest value in the RO among all countries included in the BLS (table 19).

Mainly due to the higher export of ruminant products, the terms of trade improve for New Zealand by almost 20 percent. The equivalent income is not calculated. But a cost of consumption comparison indicates that welfare increases (table 28).

The United States Boost Mainly Wheat Production. On average, the domestic terms of trade do not improve for U.S. agriculture (table 19). The strong increase of all cereal producer prices is offset by the decline especially in the milk price and that of other food (table 25). Although cereal prices go up by around 20 percent, production response varies considerably. Wheat output increases by 16 percent and that of rice and coarse grains approximately by 3 percent. The other two commodities with a noticeable change in output are dairy products and nonfood agriculture.

The retail prices vary, in general, as much as the producer prices except for coarse grains and nonfood agriculture. This also leads to considerable changes in human consumption especially to increased human consumption of dairy products (8 percent) and bovine and ovine meat (4 percent). The price elasticity of demand is larger than this of supply for these two commodities. Demand for nonfood agriculture goes down in spite of a rather strong price decline. 10/ Total GDP increases very little in the United States but that of agriculture by 1.4 percent. Based on the comparison of consumption cost, the United States realizes some welfare gains.

The EC Remains an Exporter of Wheat and Dairy Products. All agricultural prices fall in the EC. On average, they are lower by 12 percent (table 19). Mostly affected are the cereals, protein feed, and nonfood agriculture (table 26). Among the cereals, wheat shows the strongest price decline. This decline leads to a shift in production in which wheat decreases by 22 percent and coarse grain increases by 4 percent. 11/ The change in production is not

10/ Demand for cotton (cotton is aggregated into nonfood agriculture and constitutes a large share of it) depends on supply in the model.

11/ The own price elasticities of supply for these two products are -0.8 for coarse grains with respect to a changes in wheat price and -0.7 for wheat with respect to a change in the coarse grains price.

Table 23--Production, net exports, disappearance, and prices in 1990: Values in reference scenario and changes to multilateral trade liberalization for Japan

Commodity	Reference scenario 1/			Change over reference scenario					
	Production	Net exports	Feed	Production	Demand	Net exports 2/	Feed	Retail prices	Producer prices
				Percent					
Wheat	0.76	-7.52	2.96	-8.8	-1.5	0.7	-4.4	-4.8	-14.9
Rice	10.74.	-.53	2.49	-34.4	34.1	1,450.3	133.8	-44.6	-66.2
Coarse grains	1.10	-27.19	25.32	-12.9	.1	.9	-.3	-18.7	-20.9
Bovine and ovine meat	.64	-.34	0	-3.6	3.3	16.3	0	-18.9	-19.2
Dairy products	9.29	-.67	.36	7.1	4.9	-26.2	7.5	-16.6	-27.4
Other animal products	2.13	.18	.12	10.0	6.3	50.2	27.3	-19.2	-23.6
Protein feed	1.02	-2.92	2.72	-7.3	37.7	53.6	54.3	-48.7	-48.7
Other food	5.90	-1.76	.23	-3.1	9.0	49.7	15.9	-11.7	-28.9
Nonfood agriculture	.64	-1.32	0	-7.0	.6	4.4	0	-49.9	-49.9
Nonagriculture	621.39	7.40	0	.4	0	29.9	0	--	--

-- = Approximately zero.

1/ See table 1 for units of measurement.

2/ A number smaller than -100 indicates a switch in trading position. The change is calculated as trade value, in current scenario divided by that in reference run minus unity and expressed as percentage.

Table 24--Production, net exports, disappearance, and prices in 1990: Values in reference scenario and changes to multilateral trade liberalization for New Zealand

Commodity	Reference scenario 1/			Change over reference scenario					
	Production	Net exports	Feed	Production	Demand	Net exports 2/	Feed	Retail prices	Producer prices
				Percent					
Wheat	0.36	-0.03	0.12	-1.5	-6.0	-59.0	-18.9	4.0	16.4
Rice	0	-.01	0	0	1.2	1.2	0	4.6	21.9
Coarse grains	.97	.43	0.53	2.6	-18.7	29.8	-19.1	13.3	16.8
Bovine and ovine meat	1.61	.95	0	13.0	.7	21.6	-23.0	12.7	25.7
Dairy products	7.43	4.76	.95	10.7	2.3	15.5	5.6	21.1	37.9
Other animal products	.03	.01	0	-23.0	1.3	-97.2	0	-10.1	-13.8
Protein feed	.09	.04	.05	10.9	-20.4	48.9	-21.6	10.9	10.9
Other food	.29	-.03	0	-12.6	.8	117.2	-23.0	-.6	-1.3
Nonfood agriculture	.52	.41	0	11.6	25.9	7.8	0	-10.6	-10.6
Nonagriculture	12.50	-1.34	0	0	3.2	32.6	0	--	--

-- = Approximately zero.

1/ See table 1 for units of measurement.

2/ A number smaller than -100 indicates a switch in trading position. The change is calculated as trade value, in current scenario divided by that in reference run minus unity and expressed as percentage.

Table 25--Production, net exports, disappearance, and prices in 1990: Values in reference scenario and changes to multilateral trade liberalization for the United States

Commodity	Reference scenario 1/			Change over reference scenario					
	Production	Net exports	Feed	Production	Demand	Net exports 2/	Feed	Retail prices	Producer prices
				Percent					
Wheat	85.70	51.06	10.63	16.7	-1.6	29.2	-4.0	22.6	17.3
Rice	6.23	4.55	0	3.4	-.9	4.8	0	19.2	22.2
Coarse grains	287.05	83.07	161.15	2.3	1.1	3.6	1.3	5.5	17.3
Bovine and ovine meat	12.78	-1.33	0	.2	4.1	41.7	0	-1.2	-1.5
Dairy products	64.99	2.31	.91	-4.5	7.8	-340.2	-4.5	-22.5	-23.2
Other animal products	2.46	.25	0	1.6	-4.3	53.0	0	9.6	9.5
Protein feed	23.81	13.93	9.08	.6	2.2	-0.4	2.3	10.9	10.9
Other food	14.67	3.16	0	-1.9	.8	-11.7	0	-5.7	-6.0
Nonfood agriculture	2.61	-0	0	-6.4	-5.5	3,726.6	0	-16.1	-28.1
Nonagriculture	3,373.54	-7.13	0	0	.1	20.3	0	--	--

-- = Approximately zero.

1/ See table 1 for units of measurement.

2/ A number smaller than -100 indicates a switch in trading position. The change is calculated as trade value, in current scenario divided by that in reference run minus unity and expressed as percentage.

Table 26--Production, net exports, disappearance, and prices in 1990: Values in reference scenario and changes to multilateral trade liberalization for the EC

Commodity	Reference scenario 1/			Change over reference scenario					
	Production	Net exports	Feed	Production	Demand	Net exports 2/	Feed	Retail prices	Producer prices
				Percent					
Wheat	64.08	20.27	18.75	-21.8	3.3	-79.4	13.0	-12.4	-35.1
Rice	.82	-.24	.31	-24.5	.1	84.6	-4.2	-14.6	-28.7
Coarse grains	77.25	-12.49	72.53	4.5	-2.3	-43.0	-3.1	-17.5	-20.0
Bovine and ovine meat	10.07	-.51	.01	-4.0	3.0	139.5	-4.2	-3.3	-6.1
Dairy products	112.09	9.39	19.48	-2.2	-.4	-23.2	-4.2	-1.8	-3.5
Other animal products	2.67	.08	0	-3.6	1.1	-162.6	0	-9.9	-13.4
Protein feed	1.15	-5.64	6.73	-2.3	-5.4	-6.0	-5.4	-18.9	-18.9
Other food	16.11	-5.95	.96	-4.8	1.8	19.6	-15.0	-3.9	-9.0
Nonfood agriculture	1.04	-2.00	0	-8.1	7.2	15.3	0	-28.7	-28.7
Nonagriculture	1,109.63	10.35	0	.3	.1	25.9	0	--	--

-- = Approximately zero.

1/ See table 1 for units of measurement.

2/ A number smaller than -100 indicates a switch in trading position. The change is calculated as trade value, in current scenario divided by that in reference run minus unity and expressed as percentage.

strong enough to bring about a switch in the trading position of these two grains, although demand develops for each commodity in the opposite direction. Since wheat becomes relatively cheaper than coarse grains, it substitutes for coarse grain in the feed rations, leading to an increased use of wheat as feed while that of coarse grains falls together with that of protein feed and other food. The drop in feed use is, of course, a result of the reduced livestock production. Lower feed costs cannot offset the decline of livestock prices so that the net revenues of all animals fall but considerably less compared with those of crops. The outmigration of labor (6 percent) and reduced investment in agriculture (2 percent less capital) shift the production possibility frontier unfavorably inward for the livestock sector so their production decreases, although net revenue changes do not indicate this. This decrease is not very strong, however; 4 percent for bovine and ovine meat, 2 percent for milk, and 4 percent for other animal products. The remaining crops are also produced less, especially rice (24 percent) and nonfood agriculture (8 percent).

The EC still exports 4 MMT of wheat and 7 MMT of dairy products under trade liberalization in 1990, according to the model results. All other commodities are imported. The agricultural self-reliance is reduced by 6 percent (table 19). EC farmers lose in income parity (10 percent). The land rent goes down by 35 percent. Based on GDP at constant prices, the agricultural sector shrinks by only 3 percent. As a whole, the EC is marginally better off. The equivalent income increases.

This concludes the brief discussion of the adjustments in those countries of a strong influence on the structure of trade in the temperate zone food products. Instead of extending it to the remaining countries represented in the BLS with a detailed model, main factors behind the changes in the world market prices are summarized.

Main Factors Behind the Changes of the World Market Prices

Although the change in each world market price will be discussed separately, one should bear in mind that these prices all influence each other and are simultaneously determined.

Price of Dairy Products. The fact that the EC and the United States with a share of global milk production in the RO of 20 and 12 percent, respectively, highly protect their dairy sector is one reason for the strong rise in the dairy price at the world market. The tariff equivalent for dairy products alone, however, does not fully explain the situation. The price rise is also influenced by changes in the size of the labor force (dairy production is the most labor-intensive enterprise), investment in agriculture, and, of course, development of feed costs. Labor and investment in agriculture depend largely on the overall profitability of agriculture, and their response to changes varies from country to country. For example, the labor force in Japan shrinks by less than 4 percent, which, together with the relative improvement of net revenue, leads to an increase in milk production. Also, Canada would not expand dairy production that strongly were there not the increase in the total labor force. A similar argument can be forwarded for the EC.

Consumption of dairy products, in general, is not very price responsive except in the United States, which increases human consumption considerably. Of course, the changes in the dairy price at the retail level are smaller than

those for producers, which is one reason why human consumption does not react to world market price changes strongly.

Price of Bovine and Ovine Meat. Similar as for dairy products two major producing countries, the United States and the EC, protect their producers of bovine and ovine meat. Farmers in these countries face a price decline and cut back or do not change their output. At the same time, demand increases in these countries. With the exception of Argentina, which has a strong comparative advantage in bovine and ovine meat production, all other countries do not respond with a substantial production increase to the rise in world market prices.

Prices of Wheat Many countries indicate a positive tariff equivalent for wheat (table 11). Among them are countries with a sizable production share like Australia, Canada, India, and the EC, all of which are exporters. By far, the highest tariff equivalent is shown to be imposed by the EC. Hence, quite a price incentive from the world market is needed to recover the production loss (EC and India) or to offset the domestic price decline to maintain or even increase production (Canada and Australia). Largely the United States and somewhat Australia and Pakistan step up their wheat export.

Total demand for wheat does not respond strongly to the price changes, neither human consumption nor feed use.

Price of Coarse Grains. What was said for wheat demand holds also for coarse grain demand. To make up for the loss in output in some countries with a sizable share in coarse grain production (Australia and Canada), the world market price must go up because of a rather low price response in the United States. The shift of the EC into coarse grain production certainly has a dampening effect on the price increase.

Price of Rice Japan mainly causes the rice price to rise. After removing the protection, Japan buys a substantial amount of rice on the international market. The two main rice producing countries (China and India) respond to the price rise either not at all (China, by assumption) or only marginally. A substantial price incentive is needed for the producers with a relatively small share in production to at least export 60 percent of the additional import requirements of Japan.

Price of Protein Feed. Two major producers of protein feed, the United States and Brazil, both together having an export share of 85 percent in 1990 in the RO, do not protect this commodity. Since the grains (especially coarse grains for the United States) are the major competing crops, the protein feed price must increase; otherwise, the acreage would be allocated to grains and production would decline. The price incentive is too small for the United States to expand protein feed production. Only Brazil meets the additional import needs that come mainly from Japan, which uses it as feed in producing pork, poultry, and eggs.

Price of Other Animal Products. Other animal products have a rather high price elasticity of supply so only little price incentive is needed to compensate lost production in one country by others. But these products are also relatively little protected.

Price of Other Food. Many developing countries tax the export of these products to raise government revenue. The developing countries together have a production share of about 67 percent. Removing the taxes gives farmers incentives enough to make up for the output reductions in the developed market economies. These economies impose a small positive protection in the reference run that is in nominal terms as large as in real terms and, therefore, reduces the domestic price of this aggregate relative to the other agricultural products in many of those countries.

Price of Nonfood Agriculture. A similar argument as for other food can be forwarded for nonfood agriculture. Again, most developing countries tax the export of this commodity. This tax is in real terms even larger than in nominal terms. Hence, the developing countries compensate the production cuts in developed market economies because of a sufficient price incentive.

Nominal Versus Real Tariff Equivalents

The discussion on changes in domestic producer prices showed that they adjust to a level that sometimes could not be expected from looking at the tariff equivalents in table 11. The reason, of course, is that the world market prices also change and, thereby, dampen or reinforce the effect of the removal of the tariff equivalent. The countries with a positive protection have to adjust less, and those with a negative protection have to adjust more when the corresponding world market price increases.

Those tariff equivalents, which one obtains by taking the world market prices obtained under multilateral trade liberalization for comparison, are called real because they indicate the extent of real protection and cannot be claimed to be imposed in retaliation against some other countries. They show how strong the price adjustment will be if all countries move to liberalized trade in agriculture over and above the change due to the removal of the tariff equivalent. As an example, we provide the nominal and real tariff equivalents for the EC and the year 2000 in table 27.

From table 27, one can observe that given all the assumptions made with regard to protection in the reference run by 2000, the EC has a zero real tariff rate for ruminants. Of all other commodities, the real tariff rate is around 20-30 percent with the exception of rice (41 percent) and nonfood agriculture (54

Table 27--Nominal and real tariff equivalents of the EC, 2000 1/

Item	Tariff equivalents		Item	Tariff equivalents	
	Nominal	Real		Nominal	Real
	Percent			Percent	
Wheat	112	32	Other animal products	24	16
Rice	61	41	Protein feed	36	22
Coarse grains	37	26	Other food	12	18
Bovine and ovine meat	12	3	Nonfood agriculture	28	54
Dairy products	34	-3			

1/ Nominal is measured in relation to the reference world market prices (table 11), and real is measured in relation to the free trade world market prices.

percent). The high nominal protection for dairy products that many countries exercise pushed the real protection rate of this commodity in the EC to zero.

Production and Trade Shares of Developed Market Economies and Developing Countries

An interesting result of this trade liberalization scenario is the shift in animal production between developed market economies and developing countries. Developed market economies increase their production share of other animal products, while developing countries increase their production share of bovine and ovine meat. As mentioned earlier, the developing countries as a group even become net exporters of bovine and ovine meat. A small increase in the share of milk production can be observed for the developed market economies but hardly any change in the trade share takes place. Wheat and coarse grains are not strongly adjusted in production and neither in trade between these two country groups, but trade in rice is. Developing countries become a net exporter of rice and increase their share in both production and trade of other food and nonfood.

Welfare Gains From Trade Liberalization in Agriculture

Table 28 indicates whether a country gains or loses from trade liberalization. We saw already that most of the countries discussed so far gain in terms of equivalent income or in cost of consumption.

Looking at the developing countries not yet discussed, no general pattern can be found. In terms of income, almost all developing countries gain with the exception of Brazil, Mexico, and Egypt of which the latter gains in other indicators. Brazil and Mexico lose in all of them. All three countries indicate quite a strong factor rigidity. They withdraw resources from the nonagricultural sector to be used in agriculture (table 19), although the marginal productivity of these factors is higher in nonagriculture. In other words, the inverse process takes place under trade liberalization, which in the reference run retained resources in agriculture in spite of a higher return in nonagriculture.

In terms of economic welfare, losing countries in addition to the two already mentioned are India and Indonesia. Their equivalent income or cost of consumption changes negatively. Together with Argentina and Thailand they also do not show any gains in terms of hunger and life expectancy . Given these negative impacts of trade liberalization on some countries, an international redistribution scheme may be necessary to compensate them for the losses to get them to accept the kind of liberalized agricultural trade policy as discussed in this section.

The Impact of a 1-Year 5-Percent Drop in U.S. Crop Production

In this section, the impact of an assumed 1-year 5-percent drop in U.S. crop production is analyzed. We abbreviate this scenario by US-CRS. The specification of the assumption of a 5-percent crop reduction was done in the U.S. model in a way that all crop yields fall by 5 percent in 1986. The acreage allocation was not changed, nor was the livestock sector model. The tables presented in this section have the short-term response reported in columns headed 1986 and the long-term response in columns headed 1990.

Table 28--Welfare gains from trade liberalization in agriculture 1/

Country	GDP/CAP 2/	Equivalent income	Utility indicator	People hungry	Life expectancy	Cost of consumption
			Change			
United States	n.s.	--	--	--	losses	gains
Canada	n.s.	n.s.	n.s.	--	losses	indet 3/
Australia	gains	losses	losses	--	n.s.	gains
New Zealand	gains	--	--	--	gains	gains
Austria	gains	gains	gains	--	gains	gains
EC	gains	gains	gains	--	gains	gains
Japan	gains	gains	gains	--	gains	gains
CMEA 4/	n.s.	--	--	--	--	indet 3/
China	--	--	--	--	--	indet 3/
Argentina	gains	gains	gains	losses	losses	gains
Brazil	losses	losses	losses	losses	losses	losses
Mexico	losses	losses	losses	n.s.	losses	losses
Egypt	losses	gains	n.s.	gains	losses	gains
Kenya	gains	--	--	gains	gains	gains
Nigeria	gains	gains	losses	gains	n.s.	gains
India	gains	losses	--	n.s.	n.s.	indet 3/
Indonesia	gains	losses	losses	losses	losses	losses
Pakistan	gains	gains	gains	gains	gains	gains
Thailand	gains	--	--	losses	n.s.	gains
Turkey	gains	gains	gains	n.s.	gains	gains

-- = Not calculated.
1/ n.s. = Not significant.
2/ GDP at constant prices.
3/ Indeterminate.
4/ Council for Mutual Economic Assistance.

As the models are constructed, the impact of a change in U.S. crop production on other countries affects only demand and changes in stocks in the first year. At the time the assumed production cut occurs in the United States, output is determined in all other countries, including those in the southern hemisphere, without information about the U.S. production change. Hence, the first year responses represent the demand effect in all countries dampened by changes in stock levels.

Only in the following years does production in all other countries also respond. How strong this response is depends on the changes in world market prices due to the production change in the United States, the transmission of these changes onto the domestic markets, and the price elasticities of production.

The Short-Term Responses. Table 29 indicates the changes in prices, supply, production, and net trade at the world market between the RO and the US-CRS.

In 1986, the year of the production shortfall in the United States, prices increase rather substantially for some commodities. The price rise is strongest for protein feed and coarse grains for which the share of production on global output is largest in the United States. Price increases for protein feed are 13 percent and for coarse grains 12 percent. Reductions in global production for protein feed are 2.2 percent and for coarse grains 1.5 percent.

The price increases lead, first of all, to a reduction in stocks of all commodities (table 30). As a result, the supply changes are very small except for protein feed and coarse grains (table 29). One might argue that these price increases are necessary to trigger stock releases for compensating production shortages in the United States. The ratio of global stock level to global production is much smaller for protein feed than for coarse grains. This explains why the changes in supply at the global level are relatively smaller for coarse grains than for protein feed, although coarse grain stocks are reduced only 11 percent compared to 15 percent for protein feed.

In 1986, almost all countries release stocks, except India and the socialist countries. The United States' stock management does not differ much from that of the other countries as far as releasing stocks is concerned. In 1990, when stockpiles are increased again, the United States takes the lead in smoothing out price variations, especially for rice and for wheat. The price variations in wheat is interesting because the United States takes wheat out of the market and stores it in spite of the drop in the international wheat price while other countries release it from stocks . This is possible because the United States' behavior with regard to stockpiling is assumed to be different from that of all other countries that act in their own interest.

Table 31 shows the adjustments taking place in demand for wheat and coarse grains in 1986. In general, the adjustments are rather small. Demand for both commodities is slightly increased. These demand adjustments are more or less determined by changes in feed consumption as can be seen in table 32. This table depicts the adjustments in feed consumption for countries that hold a high share in global feed use. As can be seen, the grains and other food, by and large, substitute for protein feed in the feed ration in 1986. The only exception is Canada, which replaces coarse grains in the feed rations.

To summarize, the short-term adjustments are accomplished by substituting protein feed by other feed items in the feed rations. This, in turn, leads to the demand changes as indicated in table 31 for individual countries and further to the changes in trade and total disappearance at the global level as shown in table 29.

The adjustments outside the United States are summarized in net trade elasticities. These elasticities indicate the import or export response of the world, less the United States, to a change in the world market prices as it occurs in these runs. 12/ It is assumed in these calculations that the United States match the changes in imports (or exports) in other countries. Hence, the elasticities represent the percentage change of export (or import) by the United States to a 1-percentage point change in the world market price. The elasticities are not arrived at in the usual way by an isolated change of the world market price of only the commodity concerned. The net trade response of the countries outside the United States is reached while all

12/ These elasticities may change when one analyzes the same production cut in the United States but starting from a different reference situation.

Table 29--Changes in prices, supply, production, and net trade between reference run and US-CRS at world market level, 1986

Commodity	Prices		Supply,	Production		Net exports	
	1986	1990	1986	1986	1990	1986	1990
				Percent			
Wheat	4.3	-2.5	0	-0.8	0.9	-0.7	0.4
Rice	2.1	0	0	-.1	.2	-3	1.9
Coarse grains	11.8	-2.8	-.6	-1.5	.3	-5.9	.6
Bovine and ovine meat	2.5	-.8	0	0	.1	.6	-.1
Dairy products	1.7	-1.2	0	0	.2	1.3	4.6
Other animal products	.8	-1.0	0	0	0	.6	2.1
Protein feed	13.4	2.1	-1.8	-2.2	-.6	-3.9	.7
Other food	2.9	-.3	-.1	-.3	.1	-1.8	.7
Nonfood agriculture	4.4	-.3	-.2	-.3	-.3	.9	1.5
Nonagriculture	--	--	0	0	-0	2.3	-2.6
Total agriculture	3.5	-.8	--	--	--	--	--

-- = Not applicable.

Table 30--Changes in stock levels between reference run and US-CRS, 1986 and 1990

Commodity	World		United States	
	1986	1990	1986	1990
		Percent		
Wheat	-4.8	-1.2	-3.5	6.8
Rice	-1.5	-.8	-6.5	76.9
Coarse grains	-11.4	5.8	-16.2	6.2
Bovine and ovine meat	-2.1	0	0	0
Dairy products	-1.4	1.0	-5.6	9.6
Other animal products	-.8	0	-2.6	140.6
Protein feed	-14.9	3.2	-5.1	-1.1
Other food	-5.2	0	-5.5	-1.2
Nonfood agriculture	-9.9	-1.7	-13.3	.7

world market prices change and they do so at different levels. As pointed out earlier, the short-term elasticities reflect only the adjustments on demand and stock holding. Therefore, they can be expected to be negative.

According to these results obtained with the BLS, the response of the world less the United States would vary considerably across crops 13/ (table 33).

13/ The interested reader may also refer to the work done by Ralph Seeley of the U.S. Department of Agriculture, who calculated these elasticities in a different way and published the result in Price Elasticities From the IIASA World Agricultural Model, ERS Staff Report No. AGES850418 (1985).

Table 31--Changes in demand and production of wheat and coarse grains in the various countries, 1986 and 1990

Country	Wheat			Coarse grains		
	1986, demand	1990		1986, demand	1990	
		Demand	Production		Demand	Production
	Percent					
Argentina	0.4	0.3	1.1	0.3	0.4	0.6
Australia	1.24	1.2	4.2	-.1	-.2	2.0
Austria	0	0	.8	-0	0	.4
Brazil	.9	.4	.2	-2.0	.7	.1
Canada	2.2	1.6	3.2	-1.9	.9	-.6
Egypt	.1	.1	1.7	-.5	.1	.6
Indonesia	.4	-.1	-	-.2	.1	-.8
India	-.1	.2	0	-3.5	1.1	-.1
Japan	-.1	1.4	1.3	0	1.4	1.3
Kenya	-.5	-.2	2.5	-2.5	.5	-1.2
Mexico	.5	-0	1.0	.3	0	1.7
New Zealand	-0	.5	1.3	-4.3	1.3	-2.5
Nigeria	-.5	.4	0	--	.2	0
Pakistan	.1	-.1	.3	0	.1	.5
Thailand	.9	0	--	-.5	-2.2	-1.4
Turkey	.1	.8	2.3	-.9	.2	-2.1
United States	-1.0	-.1	1.2	-.3	.7	.5
EC	.9	.5	1.2	.8	.2	.3

-- = Approximately zero.

Table 32--Changes in feed use of wheat, coarse grains, protein feed and other food in countries with a high share in global feed use, 1986 and 1990 1/

Country	Wheat		Coarse grains		Protein feed		Other food	
	1986	1990	1986	1990	1986	1990	1986	1990
	Percent							
Argentina	2.3	0.3	0.3	0.4	-2.3	0.4	3.5	0.9
Australia	3.1	-.2	-.1	-.7	-4.6	-1.5	3.6	0
Brazil	4.9	1.8	-2.8	.9	-1.4	-.4	2.7	.4
Canada	5.0	1.6	-2.2	1.0	1.9	0	2.2	.9
Japan	-.3	3.8	0	1.5	-3.7	2.4	1.0	2.2
United States	-1.3	1.2	.2	1.0	-2.1	-.6	--	--
EC	2.1	.8	1.0	.3	-6.2	.4	2.2	1.9

-- = Approximately zero.

1/ The other countries, which also have a relatively high share in global feed use (Council for Mutual Economic Assistance, China, and India), do not change their feed consumption.

The strongest response is indicated by other food with an elasticity of above 6 (in absolute terms). The response of rice is half of that, and the response of wheat and coarse grains is around -1.

The net trade elasticities for animals are more difficult to interpret . The one for bovine and ovine meat is zero because the U.S. import quota on this aggregate is binding. Other animal products show an elasticity of about minus unity, and dairy products have a positive elasticity. It is obviously cheaper for some countries to import more dairy products than to produce them domestically and to import the more expensive feedstuff. 14/

Since the U.S. farmer is more interested in knowing these responses from abroad in terms of U.S. prices, the price transmission elasticity implicit in the U.S. model is also reported. In the short term, these elasticities are all less than or equal to one (table 33). Only for protein feed is the world market price variation fully transmitted onto the domestic market. All price transmission elasticities are (implicitly) a function of the share of the farm price on retail price. The higher this share the higher is the price transmission elasticity. But since these elasticities are less than unity, the percentage increase or decrease in buying from or selling to the U.S. market is smaller when the U.S. price changes are used as bases than when the world price changes are considered.

The Long-Term Responses. The world market changes 5 years after the crop production shortfall are interesting because all but the protein feed prices decline compared with the reference run scenario (table 29, 1990). Production, in general, reaches a slightly higher level and also trade, by and large, expands. Changes in stock levels are small. More commodities indicate increasing stocks than decreasing stocks (table 30).

14/ The magnitude of the elasticity may be misleading because the U.S. export of dairy products is very small; less than 1 percent of production.

Table 33--Net trade and supply price transmission elasticities with regard to changes in the world market price, for the United States; after an assumed crop production shortfall of 5 percent in the United States

Commodity	Net trade elasticities		Price transmission elasticities	
	1986 1/	1990 2/	1986 1/	1990 2/
Wheat	-1.40	0.01	0.84	0.74
Rice	-3.03	-.90	.80	4/
Coarse grains	-.91	-.43	.78	.88
Bovine and ovine meat	--	-.19	.46	1.36
Dairy products	8.17	-6.06	.65	.58
Other animal products	-1.28	-4.36	.56	.28
Protein feed	-.51	-.64	1.00	1.04
Other food	-6.43	1.57	.61	1.06
Nonfood agr. 3/	4/	4/	.51	-.46

1/ First year after the assumed crop production shortfall.
2/ Five years after the assumed crop production shortfall.
3/ This commodity is imported by the United States.
4/ The base value is very small.

Adjustments of wheat and coarse grains with regard to demand and supply are indicated in table 31 for the year 1990. Demand changes are smaller than variations in production. But in no case are there drastic changes taking place any more. Also, the substitution processes in feed use settle down to a small magnitude (table 32).

According to these small percentage changes in both U.S. trade and in world market prices, the net trade elasticities become less stable or robust. The changes are often beyond the precision a model system, like the BLS, can claim to fulfill. Nevertheless, for completion, they have been included in table 33.

The price transmission elasticities in 1990 are difficult to interpret. A negative transmission is caused by a binding trade quota as in the case of nonfood agriculture. But also the increase in the transmission elasticity of the bovine and ovine meat price is caused by the increasing impact of the import quota. The quota is constant between the reference run and the US-CRS, but the world market price falls. The domestic bovine and ovine meat price, however, is not allowed to fall as much in 1990 as it increases in 1986 relative to the corresponding world market prices. The differences in the other price transmission elasticities between 1986 and 1990 are, in general, a result of differences in the margins. 15/ The margins are a function of past domestic prices and the development of those begins to differ in 1986. In other words, the margins are the same in the United States for both scenarios in 1986 but not any more in 1990.

Although the elasticities are difficult to interpret, the small changes taking place suggest the interpretation that the adjustments in the long term, that is 5 years after the crop production shortfall, are minimal.

15/ The U.S. model transmits the world market retail price onto the domestic retail price and derives from the latter the domestic farmgate price. All other models in the BLS transmit the world market raw material price, the price the world market is solved with, onto the domestic producer price.

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