

Thursday, December 20, 2001

**TRADE LIBERALIZATION IMPACTS ON AGRICULTURE:
PREDICTED VS. REALIZED**

**Draft for comments
By
Chantal Line Carpentier**

Environment, Economy and Trade, CEC

This report reviews the economic and environmental predictions that have been made so far regarding the environmental impacts of agricultural trade liberalization in North America. The report reviews and compares *ex ante* analyses and *ex post* analyses of NAFTA, with the aim of improving upcoming modeling for the free trade agreement of the Americas (FTAA). General trends of agricultural trade in the NAFTA countries are also presented. A literature review of models is then used to predict possible economic and environmental impacts of trade liberalization. The report concludes with a review of potential model development strategies to improve predictions of environmental impact following trade liberalization.

Trade theory tells us that heavy subsidization of agriculture in developed countries, in the form of market price support, has led to intensification and specialization of agriculture, and to domestic surpluses that are exported on the world market, lowering world prices (Lankoski, 1997). Trade theory also predicts that complete agricultural trade liberalization should lead to increased grain production in developing countries that have traditionally taxed their agricultural sector and thus currently use relatively small amounts of pesticides and commercial fertilizers per hectare (OECD, 2001). Conversely, grain production should decrease in developed countries with high input per hectare. Similar shifts are predicted for livestock production; OECD (1991) concludes that trade liberalization will likely result in a shift in livestock production "from countries with protein intensive feeding diets [confined animal feeding] to others with more carbohydrate-intensive [grass-based]..." diets (OECD, 2001, p.14).

These predictions, however, assume perfect competition, that is, that there are no trade distortions or externalities. However, NAFTA and the GATT Uruguay Round of multilateral trade negotiations (UR) were far from reaching a state of perfect competition. This suggests that classical trade theory is inadequate to predict the effects of these trade agreements. In this second-best world, impacts must be estimated empirically, and it is not known *a priori* which sectors would gain from liberalization nor by how much.

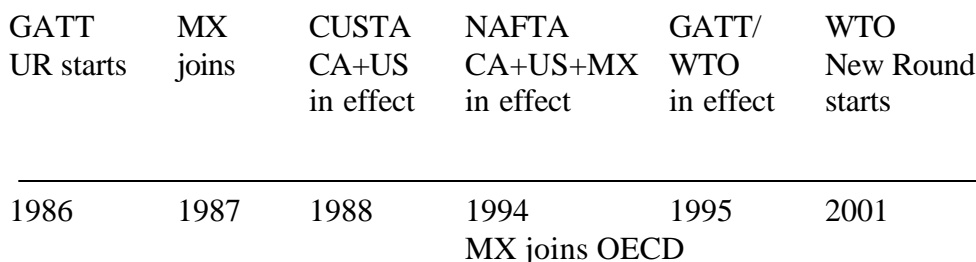
Starting with NAFTA negotiations, governments and academia started using general equilibrium models (GEMs) to estimate how various economies would fare under various negotiation positions—in other words, to do *ex ante* analyses. To find out which sectors

within agriculture would win or lose under various positions, GEMs were adapted or created for the agricultural sectors. Five years after the beginning of NAFTA, authors have gone back and assessed the effects of NAFTA (and UR) on agriculture. These *ex post* analyses estimate which part of the trends observed since NAFTA can be attributed to NAFTA, rather than to other factors, such as already established trends in place prior to NAFTA, the peso crisis, the devaluation of the Canadian dollar, or other regional trade agreements.

This paper reviews both *ex ante* and *ex post* analyses. Feedback from *ex post* analyses may make it possible to improve the accuracy of *ex ante* analyses for upcoming trade liberalization. Carslon et al. (1994) argue that improvements to *ex ante* models based on *ex post* analyses are too seldom performed in the field of resource economics (including agriculture).

A review of *ex ante* predictions made about the effects of NAFTA on U.S., Canadian, and Mexican agriculture suggests that the predictions for broad commodity categories were generally in the right direction, though rarely of the right magnitude. Revenues and price predictions were generally overestimated, and some trade patterns were not foreseen. The trade created between Canada and U.S. had been dismissed as small by *ex ante* modelers but turned out to be very important, especially in food processing, but also for bulk commodities. For instance, increases in Canadian exports of tomatoes by 3000% and of butter and butterfat by 2500% to the U.S. were not predicted, nor was the two-way trade in beef and veal between Canada and the U.S.. In addition, *ex ante* analyses predicted increases in commodity prices, which were expected to permit reductions in government transfers to support farm incomes. Agricultural commodity prices were high in 1993-94 when the negotiations were being made and in 1994-95 when they came into effect. Prices were not predicted to decrease sharply in any of the agricultural outlooks made at that time, and therefore modeling predictions were based on these high prices. However, most commodity prices have in fact decreased since the 1993-1995 period.

AGRICULTURAL TRADE AGREEMENTS AMONG THE THREE COUNTRIES



Revision of broad agricultural policies other than just tariffs was first seriously discussed in 1986 at the start of GATT UR. These provisions were ratified in Marrakesh in 1994. At the same time, the WTO was created to oversee the implementation of these

agreements. Nine countries or country groups presented their proposals in 1989 to be considered by the agricultural negotiating group.

Mexico joined the OECD in 1994, and is the OECD country with the sixth largest agricultural sector. Maize and beef are its major agriculture commodities. Agriculture still accounts for 6% of the Mexican GDP, compared to 2% in the U.S. and Canada (OECD, 2001). More importantly, the agriculture sector employs 19% of the work force in Mexico, compared to 5% in Canada and 3% in the U.S. (OECD, 2001).

NAFTA negotiations occurred parallel to the UR and addressed similar agri-food issues, as well as incorporating most of the Canadian/U.S. Trade agreement (CUSTA) measures. During the NAFTA negotiations, it was assumed the UR would be concluded first, but in fact, NAFTA was concluded in August 1992 and came into effect January 1994, while the UR was not concluded until December 1993 and came into effect for most agri-food products only in August 1995 (Hahn et al., 1990). The current implementation period of the Uruguay Round commitments for most OECD countries ends in the year 2000. Because of its developing country status in the WTO, Mexico has until 2004 to implement its UR commitments and to adjust tariff rate quotas, tariff rates, and export subsidies. The NAFTA implementation period is longer, up to 10 or 15 years depending on commodity, with most provisions to be fully in place by 2008.

- NAFTA agri-food provisions are similar to the provisions in CUSTA, although NAFTA is somewhat more comprehensive than CUSTA. NAFTA includes provisions regulating market access (tariffication and elimination, or phased out elimination of tariffs, over 10 years for most commodities and 15 years for sensitive commodities). After the 15-year implementation period, agri-food trade between Mexico and U.S. will be tariff-free (many tariffs were eliminated in 1994). However, tariffs on poultry, dairy, sugar and egg products will still apply between Canada and Mexico and between Canada and the U.S. (Meilke and van Duran, 1996; OECD, 1996).
- Tariff rate quotas were imposed on milk, butter, cheddar cheese, skim milk powder, yogurt, ice cream, chicken, turkey, and eggs between Canada and Mexico. Above-quota tariffs were near or above 200%, and were set to decrease 15% by 2001, while within quota tariffs were closer to 15% and set to decrease by 57% by 2001 (www.AMAD.org lists all tariffs by country and commodity, and Meilke and van Duran, 1996, list the schedule of tariffs among the NAFTA countries).
- Unlike CUSTA, NAFTA does not explicitly ban the use of export subsidies. Although Canada and the U.S. cannot use subsidies on exports to each other's market, some U.S. export subsidies are allowed for basic food commodities sold to Mexico.
- NAFTA preserves the Canadian supply-management system (requiring import quotas) under negotiation for the UR. These provisions do not exist between U.S. and Mexico.
- Sanitary and Phytosanitary (SPS) measures of the GATT form the basis of provisions contained in NAFTA. Dispute settlement procedures is the same as in CUSTA but for the three countries.
- Each country retains its own contingency protection laws, countervailing duties, and anti-dumping laws.

- A dispute settlement panel is chosen from a tri-national roster (Meilke and van Duren, 1996).

NAFTA was expected to cause only small changes in agricultural trade between the U.S. and Canada, because it incorporated the already-existing CUSTA agreement between these two countries (Economic Research Service of the U.S. Department of agriculture ERS, 1993) and because both countries are large exporters. NAFTA was also not expected to increase agricultural trade between Mexico and Canada, because trade between these countries was very limited, and because both maintained trading restrictions relative to the other. In contrast, NAFTA was predicted to have a substantial impact on U.S. and Mexican agriculture, because Mexico had not been previously been involved in similar agreements.

It is important to note that asymmetrical trade relations existed between the three NAFTA countries prior to this 1994 agreement. Because of the scale of the U.S. economy and magnitude of its foreign agricultural trade, Canada and Mexico relied much more on the U.S. as a trading partner than the U.S. did with either country. In addition, there was relatively little trade between Mexico and Canada. For instance, in 1993, Canada's agri-food imports from the U.S. accounted for 62% of Canadian agri-food imports, while imports from Mexico accounted for 2%. Canada's agri-food exports to the U.S. accounted for 57% of the Canadian agri-food exports and to Mexico for only 2%. Comparatively, Canada accounted for 12 % of U.S. agricultural exports and 19% of its agricultural imports (Secretary of Agriculture, 1992). Mexico accounted for 9% of U.S. agricultural exports and 11% of its imports. Thus, the U.S. was generally perceived as gaining significant market access to Mexico through this agreement.

Economists predicted at the time that there would be risks involved in establishing trade agreements between countries with economies as different as Mexico, the U.S., and Canada. However, it was also predicted that NAFTA would contribute to robust economic growth in Mexico, that would in turn generate effective demand for imports and would result in job creation in the U.S. and Canada. The net conclusion from these predictions was that all three NAFTA countries would benefit from this free trade agreement.

The next section reviews specific predictions about the impacts of NAFTA on agriculture by country, based on work conducted by ERS (1993) and Meilke and van Duren (1996).

NAFTA EFFECTS ON AGRICULTURE: *EX ANTE* ANALYSIS

CANADA

Because existing CUSTA rules between Canada and U.S. were merely rolled into the NAFTA agreement with little modification, and because little net impact was expected, the Canadian government did not explicitly model the potential impacts of NAFTA on Canada's agricultural sector. In 1993-95, Agriculture Canada relied on data from the

Canadian Conference Board, IMF, FAPRI, USDA, and the World Bank for its midterm outlook.

The Canadian Agricultural Midterm Outlook for 1994 was not available. However discussions with Agriculture Canada experts and revisions of documents of that time indicated that generally prices were predicted to go up, raising farm income and thus allowing Canada to meet its GATT UR requirements to reduce government support. The general prediction was that producers would be better off with NAFTA than without it. NAFTA was also expected to reduce the gap in income between the U.S. and Canada (Tim Hazledine, personal communication).

Based on analyses conducted in 1994-95, Meilke and van Duren (1996) summarized their predictions of the impact of NAFTA on the Canadian Agri-Food sector.

Canadian Beef Trade

NAFTA was predicted to have minimal impact on the beef sector, because trade in red meat was already tariff-free between Canada and the U.S. following CUSTA, and became tariff-free with Mexico under NAFTA. However, the UR's requirement to convert import barriers into tariffs and to reduce those tariffs through 2001 was predicted to have an impact on non-NAFTA imports. For example, NAFTA provisions, in combination with WTO's technical regulation and market access provisions, were predicted to increase NAFTA beef exports to EU and Japan. The CUSTA had led to an increase in exports of Canadian beef to the U.S. following CUSTA. In the short term, higher technology levels in the U.S. and the mixed kill orientation of the Mexican packing industry (as opposed to higher quality and box meat orientation of Canada and U.S.) was predicted to prevent the Mexican industry from competing in this sector (Meilke and van Duren, 1996). However, in the long term, it was thought that Canada could lose business to the Mexican packing industry due to lower labor costs. Increased demand for pork and beef as the Mexican GDP increased was predicted to favor increased exports from the U.S. to Mexico and from Canada to the U.S.

Canadian Grains and Oilseed Trade

Large trade impacts were predicted in the grain, corn, and wheat sectors, but the UR was believed to overshadow any NAFTA and CUSTA impacts (Meilke and van Duren, 1996). Following the UR negotiations, all nontariff barriers to trade were converted into tariffs. Within CUSTA, the maximum 10-year implementation was retained for most cereal between U.S. and Canada, while oilseeds and feeds had been less protected, and protections that had been in place were phased out more quickly. Mexico had had the highest protection on maize and chose the longest time period available in NAFTA (15 years) to phase out tariffs on maize (10 years for other grains and feeds). The U.S. and Canada were expected to gain open access to the Mexican market in wheat and other cereals by 2003 and access to the Mexican maize market by 2008. However, access has in fact been relatively open, given that Mexico has generally not enforced the over-quota tariff on commodities such as corn and poultry when the quota has been exceeded (ERS, 1997).

Basic foodstuffs, such as bread, flour eggs, rice, pasteurized milk, corn flour and products, salt, margarine, sugar, and processed products, such as roasted coffee, crackers, low-price cookies, soft drinks, tomato puree, beer, canned sardines, and tuna, were excluded from the general provisions against export taxes, to benefit the poorest Mexicans in the cities.

Canadian Dairy and Poultry Trade

Canadian supply management in the dairy and poultry industries was maintained in NAFTA. Both Canada and Mexico maintained their barriers on milk and poultry, excluding dairy products from the Canada/Mexico agreement. However the U.S. and Mexico have open trade on these commodities, giving the U.S. an advantage in the Mexican market. The U.S. and Mexico were among the largest importers of dairy products in 1994. Meilke and van Duren (1996) predicted growth in exports of milk, milk products, and poultry and eggs from the U.S. to Mexico.

Canadian Horticulture Trade

Meilke and Duren (1996) predicted that the greatest effect from NAFTA would be felt in the horticulture sector. Over the long run, this impact was expected to include spatial redistribution of processing activity. For this reason, horticulture products, including potatoes, onions, broccoli, tomatoes, and cut flowers, were subject to safeguard measures in CUSTA and NAFTA, to prevent southward movement of processing for these commodities.

UNITED STATES

The ERS (1993) used economic models and analysts' judgments to predict possible impacts of NAFTA on U.S. agriculture, using 1993 as a baseline year. Trade between Canada and the U.S. had already increased with the CUSTA beginning in 1989, and the ERS predicted little additional impact on U.S.-Canada trade. In contrast, significant trade expansion with Mexico was predicted, which was expected to result in a net predicted increase of at least 0.5% percent in Mexican economic growth. NAFTA was predicted to facilitate the establishment and acquiring of food processing enterprises in Mexico and Canada through its investment clause (ERS, 1993).

In 1992, U.S. trade with Mexico was estimated at \$3.8 billion and was predicted to continue to grow under NAFTA. Population growth, urbanization, improved economic activity, and greater market access were predicted to provide additional opportunities for growth in U.S. exports of food, feed, and fiber to Mexico. Between 1987 and 1992, the proportion of higher-value products exported from the U.S. to Mexico went from 40% to 70% of total exports, and this growth was expected to continue to increase. Consumer-oriented food products, meat, poultry, horticultural products, dairy products and snack foods were among the most significant higher-value products exported from the U.S. to Mexico. Other higher-value product exports expected to expand included live animals, cattle hides, feeds & fodders, and soybean meal. U.S. farm cash receipts were expected to increase by about 3% compared to projected receipts without NAFTA. NAFTA was also expected to reduce farm program spending, given the expected growth in exports for income-supported commodities. In total, at the end of the 15-year transition period,

annual U.S. agricultural exports were expected to be \$2 to 2.5 billion higher than what was expected if NAFTA were not enacted. Grains, oilseeds, and meats were expected to account for much of this expansion.

In addition, NAFTA provisions were also expected to increase Mexican agricultural exports to the U.S., by at least \$500 to \$600 million annually. Major competitive commodities exported to the U.S. were expected to be vegetables, fruits, and cattle.

Specific commodity predictions for the U.S. agricultural industry are reviewed next.

U.S. Wheat

At end of the 10-year transition period, U.S. wheat exports to Mexico were expected to be about 1.5 million metric tons (a 20% increase in U.S. exports to Mexico over what was expected without NAFTA). U.S. wheat prices were expected rise slightly as a result of NAFTA, and the U.S. wheat sector was expected to accrue small benefits.

U.S. Coarse Grains

In 1994, the U.S. was assured a 2.5 million metric tons (mmt) duty-free quota for corn that increased at 3% per year. The above-quota tariff of 215% was to be phased out over nine years. U.S. corn exports to Mexico were expected to increase steadily, with a prediction of six million metric tons of corn exports from the U.S. to Mexico by the end of 15-year transition period. This was predicted to be as much as 60% above what would have been expected without NAFTA. Corn prices were expected to be six cents a bushel higher than without NAFTA. Sorghum exports to Mexico were also expected to be seven million metric tons greater after 10 years than without NAFTA, yielding slightly higher U.S. prices. U.S. industry revenues for corn and grain sorghum were expected to increase by \$400-\$500 million as a result of NAFTA.

U.S. Oilseeds

U.S. soybean exports were expected to reach about 4.5 mmt by the end of the transition period (a 20% increase over what was expected without NAFTA). Prices were expected to be 2% higher than without NAFTA, and revenues for the industry were expected to rise \$400 to \$500 million.

U.S. Vegetables and Melons

In 1991, U.S. imported \$1 billion in vegetables and melons from Mexico, with fresh tomatoes being the most important export commodity. Exports to Mexico were \$123 million in 1991. Tariffs were expected to be faded out over 5, 10, or 15 years, depending on the crop and season. Under NAFTA, U.S. was expected to export more sweet corn, green beans, tomato paste, and frozen asparagus to Canada. The U.S. was expected to import more cucumbers, peppers, broccoli, fresh tomatoes, and fresh asparagus and melons from Mexico. Higher prices and revenues were expected for the sector.

Pork

U.S. exports of pork and hogs to Mexico were predicted to double by the end of the transition period, resulting in slightly higher U.S. prices. At the time Mexico accounted

for about ¼ of U.S. pork exports, and it was thought that the Mexican market for pork would increase. At the same time, however, NAFTA was expected to reduce feed costs for the Mexican pork industry, making it more competitive over time and moderating growth of U.S. exports. It was predicted that U.S. prices would be 50 cents to \$1 higher per hundredweight than if NAFTA were not enacted. A small increase in U.S. production and prices was expected.

Beef

U.S.-Mexican cattle trade was expected to increase in both directions. It was thought that more young cattle would leave Mexico to be fed in the U.S., and more U.S. slaughter cattle would be shipped to Mexico. U.S. beef exports to Mexico were expected to expand to more than 200,000 metric tons by the end of the 10-year transition period. This expansion was predicted to have relatively little overall effect on total U.S. production and prices. U.S. prices for cattle and beef were expected to increase by 50 cents to \$1 per hundredweight, and industry revenues were predicted to rise \$200 to \$400 million by the end of the transition period (compared to what was expected if NAFTA were not enacted). U.S. exports of hides and skins were also expected to increase, although a specific prediction for the magnitude of this expansion was not made.

Dairy

In 1991, the U.S. exported \$121 million of dairy products to Mexico (1/3 was nonfat dry milk), while it imported only \$1.5 million of dairy products from Mexico. Mexico was not expected to become a major exporter of dairy to U.S.. However, U.S. exports of milk powder to Mexico were expected to grow about 20,000 metric tons by end of the 15-year transition period, adding \$36 million in additional dairy export sales. Other dairy products were predicted to increase \$200-\$250 million annually by the end of the transition period. Exports were expected to increase to 55,000 – 65,000 metric tons by the end of the 15-year transition, a 50% increase compared with projections without NAFTA. Nonfat dry milk sales were expected to reach as high as \$36 million, and other dairy products as high as \$200-\$250 million (15% higher than if NAFTA were not enacted).

Poultry

In 1991, the U.S. imported about 100,000 metric tons of poultry from Mexico. About 16% of U.S. poultry exports (less than 1% of total U.S. production) went to Mexico. Under NAFTA, U.S. poultry exports were expected to increase to over 1% of U.S. production and prices to rise 2% higher by the end of the 10-year transition (compared to what was expected if NAFTA were not enacted). The benefit to U.S. poultry producers was expected to be moderated by lower cost grain imports from U.S. to Mexico, which were expected to reduce production costs for the Mexican industry.

Prior to NAFTA, the U.S. supplied about 2/3 of Mexican egg imports, which represented less than 1% of Mexican consumption. It was expected that lower feed costs would stimulate greater egg production by the Mexican industry. By the end of the 10-year transition, the U.S. was expected to export 400-500 million eggs to Mexico, several times the level expected without NAFTA. This represented a small share of U.S. production, however, and was thus expected to have only small effects on the U.S. industry.

MEXICO

No models were run to predict the impact of NAFTA on Mexican agriculture. Meilke and van Duran (1996) predicted that, in general, the livestock sector should benefit more than the crop sector from NAFTA changes. The World Bank (1992) recommended policy changes that Mexico could implement to meet its commitment under a potential upcoming agricultural trade liberalization agreement. The Bank suggests that Mexico's protection of maize producers and taxation of maize consumers be eliminated. To help landless, subsistence farmers and rainfed maize producers that were expected to lose from this policy, the Bank recommended phasing out the movement to international prices over 1994-98 and also recommended that the government implement a program in 1992 to help facilitate the transition.

In sum, before NAFTA, experts' judgments along with some *ex ante* modeling efforts were used to predict the impacts that NAFTA's proposed domestic and trade policies would have on the agricultural and processing sectors of the three economies. It is often difficult to assess the accuracy of these predictions because these predictions are generally reported as percentage increase (or decrease) over what would have been expected without NAFTA. These reports rarely specify what the baseline prediction was, and few predictions of absolute volume or value are given. This makes it difficult to assess whether these predictions were accurate. This is somewhat unfortunate as a lack of feedback about the ultimate accuracy of these models makes it difficult to improve the underlying modeling strategy.

NAFTA EFFECTS ON AGRICULTURE: *EX POST* ANALYSES

Another approach to assessing the effect of NAFTA is to conduct *ex post* analyses. *Ex post* analyses (usually regression-based) are conducted retrospectively to assess the impact of NAFTA relative to variables other than NAFTA. In *ex post* analyses, the effects of unexpected events (such as the 1995 peso crisis) on agricultural trade can be accounted for and separated from presumed effects of the variables of interest (in this case, the effects of the NAFTA agreement).

Five years after the enactment of NAFTA, at least three *ex post* analyses have been conducted to evaluate the impacts of NAFTA on the agricultural sectors in the three countries. In this section, we first present trends data to provide information about general trends in pre- and post-NAFTA data (that reflect the net effects of trends, NAFTA, and other factors).¹ After reviewing these trends, we then turn to describing results of *ex post* analyses. Both current statistics and *ex post* results are subsequently compared to the predictions that were made *ex ante*.

¹ Most statistics are from the US point of view since those data are readily available on the ERS' web site. In Canada, data are kept at Statistics Canada where fees and time-delay applies to access it.

TRENDS

U.S. exports in agriculture, food, and kindred products (subsequently referred to here as 'agricultural products') to NAFTA countries increased by 51% from 1989-93 to 1994-98 (Table 1). In comparison, total agricultural exports to the world increased by 33% over the same period (ERS, 1999). U.S. imports of agricultural products from Canada increased by 76%, while imports from Mexico increased by 53%. In comparison, U.S. total agricultural imports from the world increased from \$26.2 billion in 1993 to \$38.9 billion in 1998, a 37% increase. Table 1 shows that trade with NAFTA countries has increased consistently more than total trade. Imports have grown faster than exports for the U.S., and the largest imports and exports are in agricultural products trade.

The value of agricultural imports from Canada and Mexico increased by 86%, while U.S. agricultural export value increased by 20% during the 1994-2000 period, from \$42.9 to \$51.6 billion. Exports to Mexico increased by 81% and to Canada by 44%. However, Mexico still represents only 13% of U.S. total agricultural exports and Canada 15% in 2000. Canada represents 22% of the U.S. agricultural imports and Mexico represents 13%.

Table 1. Agriculture and food trade among NAFTA countries, U.S.

	1989-93		1994-98		Change	
	TOTAL NAFTA		TOTAL NAFTA		TOTAL NAFTA	
	billion \$		billion \$		% change	
EXPORTS						
Livestock	0.9	0.3	1.0	0.4	16.3	19.3
Agriculture	23.0	3.4	27.7	5.1	20.5	49.2
Agricultural prod.	18.1	4.3	26.9	6.6	48.9	54.1
Total	42.0	8.0	55.7	12.1	32.6	50.6
IMPORTS						
Livestock	1.8	1.4	2.4	1.9	35.1	35.7
Agriculture	7.0	2.1	10.8	3.6	53.9	73.5
Agricultural prod.	16.2	3.4	21.0	6.0	29.5	75.8
Total.	25.0	6.9	34.2	11.5	36.8	67.1

Source: ERS (1999) Table 5

Total agricultural imports from Mexico to the U.S. reached \$5 billion in 2000 and imports from Canada reached \$7.6 billion (FATUS, 2001). The percentage increase in import value from Canada over 1994-2000 was 63%, while from Mexico it was 75%. The percentage increase in export value to Canada over the same period was 37%, while to Mexico it was 42% (FATUS, 2001).

U.S. exports to Mexico and Canada in all major agricultural commodities have increased since 1993 (Figures 1 and 2). To Mexico, the most significant increases were seen in U.S. exports of beef and veal, which more than quadrupled, and in U.S. exports, pork have

more than tripled, the most significant increases seen since 1993 (Figure 2). U.S. exports in grains and feed and in vegetables and vegetable products to Mexico have more than doubled since 1993.

The largest increases in exports to Canada from the U.S. were in pork, which increased 3.5 times in value, and in dairy and products, which more than tripled in value (Figure 1). Exports in beef and veal from the U.S. to Canada are the only commodity showing a decline in exports during the 1994 to 2000 period. Many other commodities increased in exports from 100% to 150% between 1993 and 2000 (Figure 1).

The largest increase in imports to the U.S. from Canada was in dairy products, which increased fourfold, and in vegetables and prepared vegetables, which increased 3.7 times (Figure 3). Tomatoes alone increased 2,521%, reaching \$161 million in 2000. Other prominent U.S. import increases can be seen in beef and veal imports (which increased 2.5 times), poultry and poultry products (which increased 2.3 times), pork (which increased 1.75 times), and sugar and related products (which increased 1.5 times). The total value of all agricultural imports from Canada to the U.S. increased 186% from 1994 to 2000.

The largest increase in imports from Mexico to the U.S. can be seen in dairy products, beef and veal, sugar and related products, and grain and feeds (Figure 4). Although trade in most agricultural products has expanded since 1986, especially in the livestock sector, three products – rice, sugar, and dairy products – are famous for their high level of protection (OECD, 1998), and have been relatively immune to changes.

These general figures however, hide important details. The increase in value of trade is often a fraction of the increase in quantity of trade. For instance, the simple ratio of change in value over change in quantity for cattle and calves, poultry, swine, feeds and fodder, corn, wine, beans, peas and lentils, and fruit juices exports from the U.S. to Canada is lower than 0.80 (calculated from FATUS, 2001). Swine is the worse case with an 80% increase in export and only a 2% decrease in value of export to Canada. Products for which the traded value increased faster than quantity (meaning these producers could be better off) are beef and veal, pork, wine, fresh tomatoes, and agrochemical and fertilizers. Fertilizer exports to Canada have decreased by 65% since 1994, but the value of exports has increased by 58%. The value and quantity of imports from Canada to the U.S. have similar growth patterns, except for fresh and processed tomatoes for which the value increases much faster. At the same time, Canadian farmers' nominal net farm income decreased by 13% between 1994-97 while real net income has decreased (OECD, 2001). U.S. net nominal farm income has increased by 62% from 1994-98 (OECD, 2001). The large decrease in the value of the Canadian may have played a role in these trends.

A similar trend is observed in some commodities from the U.S. to Mexico. The simple ratio of percentage increase in value over increased quantity for grains and feed, wheat, feeds grains, oilseeds and products, agrochemical and fertilizers exports from the U.S. to

Mexico is lower than 0.80. In contrast, values for the cattle and calf, poultry, peppers, and fresh tomato trade values have increased faster than quantity.

Contrary to predictions, international prices have also generally decreased since 1994. Between 1994 and 1999, world dairy product prices have decreased sharply (OECD, 2001). Whole milk powder and non-fat dry milk are now back or close to their 1994 values, while butter and cheese prices are closest to their 1993 level (Figure 5). World wheat, corn and oilseed prices increased up until to 1994, but have subsequently declined, bottoming out in 1999 and remaining lower than 1993 levels even today (Figure 6).

Choice steer prices have declined from 1993 to 1998 to increase slightly thereafter, but prices are still below 1993 levels (Figure 7). World hog prices increased sharply in the 1995-1997 period but declined again sharply to below 1993 levels in 1998-99. Prices in the pork sector have recently rebounded slightly to return to 1993 levels.

NAFTA is more than a trade agreement in goods; it has a very important investment clause that may have had more effects than the trade in goods. Investment in food processing has grown both in nominal and real terms since NAFTA (ERS, 1999). U.S. Foreign Direct Investments (FDI) in Mexico's food processing industry increased from \$2.3 to \$5.0 billion in 4 years from 1993-97. This \$5 billion represents 24% of the \$21 billion Mexican processed food industry. During the same period, direct investments from the U.S. in Mexico's crop and livestock production was \$45 million. U.S. FDI in Canada's food processing industry increased from \$2.5 to \$5.2 billion in 7 years from 1990-97. This \$5.2 billion is 13% of the \$40 billion Canadian processed food industry. ERS (1999) reports that two U.S.-owned flour milling companies in Canada control 75% of the wheat milling capacity in Canada, while U.S. multinationals account for 70% of Alberta's total cattle slaughter capacity, or 42% of the total Canadian slaughter capacity. ERS (1997) attributes 67% of the change in agricultural investment in Canada and 91% of the agricultural investment in Mexico to NAFTA. The share coming from FDI could not be identified. This synergy between FDI and trade needs to be better analyzed to inform future modeling efforts.

EX POST ANALYSIS

All of these changes cannot be attributed exclusively to NAFTA. In fact, the impact of NAFTA is difficult to ascertain, notably because of three factors:

- (1) NAFTA provisions have been phased in over a long implementation period.
- (2) Other free trade arrangements that came into place since NAFTA (including the GATT UR that came in effect right after NAFTA) making it difficult to isolate the effects of NAFTA- Appendix A reports predicted impacts of the GATT UR).
- (3) Macroeconomic shocks that have taken place since the beginning of NAFTA implementation obscure the effects of NAFTA (such as the peso crisis in 1994-1995, DeJanvry, Sadoulet, & Davis, 1997) and the devaluation of the Canadian dollar.

The general consensus is that the net effects of NAFTA have been to reinforce an already well-established process of trade liberalization between the U.S. and Mexico and between the U.S. and Canada. This process was well in place since Mexico's entrance into the GATT agreement in 1987, but the trend was further strengthened by NAFTA provisions. For example, while GATT reduced Mexico's average trade-weighted import tariffs to the U.S. from 25% to 10%, NAFTA furthered this reduction from 10% to 5%. Similarly, under NAFTA, U.S. tariffs to Mexico were reduced from an already low 5% to 1.5%. However, it is important to note that many of the commodities in which Mexico has a comparative advantage were already under a free trade regime before NAFTA. For example, trade liberalization for tomatoes has played a minor role in tomato trade between U.S. and Mexico, because tariffs were already low.

In the processing sector, larger food processing firms had already started migrating to Mexico. For instance, Birdseye moved some vegetable freezing and canning operations to Mexico in the late 1960s, followed by Green Giant, Campbell's soup, and Hunt (Barichello et al. 1991). Cargill Corporation moved meatpacking plant in Mexico in 1991 (Milling and Baking News, 1991). The first two years under NAFTA reinforced this pattern of specialization, although trade also affected by other economic factors. OECD (1997) also reports that in the first two years of NAFTA, exportations of grains and soybeans and other feed products from the U.S. to Mexico increased significantly more than other products.

In an early appraisal of the impact of NAFTA (on all industries) between U.S. and Mexico, DeJanvry, Sadoulet, & Davis (1997) suggest that there were no statistically significant differences pre and post-NAFTA in the growth of total imports from Mexico to the U.S. (91-93: 13% average annual growth rate in comparison to 94-96: 14%). U.S. exports to Mexico were strongly diminished at the onset of NAFTA (1/94 to 11/94: 3% compared to 13% pre NAFTA) and then by the peso crisis (12/94 to 9/95: -28%), but showed strong recovery between Oct 95 and June 96 (33% growth). The authors' analysis, based on trends predicted from population, per capita income, and real exchange rate levels, suggest that without NAFTA, U.S. exports would have been stagnant in 1994 (whereas they actually rose 18%), and they would have dropped more dramatically during the peso crisis (predicted fall 28%, actual fall 14%). Imports to the U.S. from Mexico would have been lower without NAFTA; they would have increased by 5% in 1994 rather than the observed 19%, and would have fallen by 3% in 1995 instead of the observed 17% increase.

DeJanvry, Sadoulet, & Davis (1997) also applied these models to the agricultural sector. Their results suggest that U.S. agricultural exports to Mexico in 1994 would have been stagnant without NAFTA, whereas they actually grew 24%. In 1995, they suggest exports to Mexico would have fallen by 46% instead of the observed 25%. U.S. agricultural imports from Mexico increased in 1994 and in 1995, but were not significantly different from predictions. Thus, NAFTA appears to have played an important role in helping U.S. agricultural exports to Mexico more than it has helped U.S. imports from Mexico.

Table 2. NAFTA effects on trade between the U.S. and Mexico

	Overall Trade		Agricultural trade	
	Predicted	Actual	Predicted	Actual
Exports from U.S. to Mexico				
1993	Stagnant	+18%	Stagnant	+24%
1994	-28%	-14%	-46%	-25%
Imports from Mexico to U.S.				
1993	+5%	+19%	+	+ at rate similar to predicted
1994	-3%	+17%	+	+ at rate similar to predicted

Another *ex post* analysis of NAFTA was conducted by ERS (1999). Predictions from this effort are summarized in Table 3. All values below are the proportion of trends attributed to NAFTA. ERS estimated medium-size increases in exports from the U.S. to Canada and Mexico in vegetable oils and cotton. Medium-size increases in exports from the U.S. to Canada also included wheat and wheat products and fresh tomatoes. The only large predicted increases in exports to Canada that were attributed to NAFTA were in processed tomatoes and in beef and veal.

Medium-size increased exports from the U.S. to Mexico include sorghum, beef and veal, and pork. Large increases in exports to Mexico from the U.S. include cattle and calves, dairy products, apples, and pears. ERS estimated that changes in U.S. exports of corn and of poultry meats to Canada and Mexico caused by NAFTA were low. A large reduction of imports of cattle and calves from Canada to U.S. is also attributed to NAFTA. Medium-size increases in exports of fresh and processed potatoes and fresh tomatoes from Canada to the U.S. were also attributed to NAFTA. The only large increase of imports to the U.S. from Mexico attributable to NAFTA in peanuts and sugar, while medium increase in imports in fresh and process tomatoes, and cantaloupe is also estimated by ERS (1999).² ERS (1999) concludes that NAFTA is likely to have had a small positive effect on employment in the U.S. agriculture sector mainly because the U.S. agriculture is generally not labor-intensive. Employment in agriculture has increased since 1988 but has decreased 1994, especially in livestock production. Total employment in food and kindred products has increased slightly since 1994. The decline is attributed to a consolidation within certain subsectors of the industry such as meat and dairy products (ERS, 1999, p. 32).

A third *ex post* analysis of NAFTA effects is provided in Public Citizen's Global Trade Watch (2001) report. This report, which is highly critical of NAFTA, compares predictions of NAFTA impacts that had been made by trade groups to current statistics.

² Medium trade changes are in the range of 6-15% and large changes are more than 15%.

Although this report does not account for what would have happened without NAFTA, the report is interesting in demonstrating a large discrepancy between what governments and industry groups projected would happen and what has actually happened. For example, Public Citizen reports U.S. Census data showing that the number of small farms (defined as farms with sales of less than \$100,000) has decreased by 33,000 in the NAFTA period, a rate six times faster than during the five years prior to NAFTA. Across all three countries, the consumer price index for food has risen, while prices paid to farmers has decreased. The result of these trends has been to reduce farm incomes and increase farm default rates and bankruptcy compared to prior to NAFTA. The report argues that although the volume of exports from the U.S. has increased under NAFTA, the volume of imports has increased even more, causing an agricultural trade deficit in 1995 and 1999 for the U.S.. This deficit is especially pronounced with the U.S.'s NAFTA partners. The authors compare this trend to a trade surplus that was increasing by \$203M between 1991 and 1994 before NAFTA.

EX ante and Ex post comparisons

Although it seems that *ex ante* and *ex post* analyses conducted by ERS should be easy to compare, even that comparison is not simple. In 1993 ERS predicted increases and decreases above what would have happened without NAFTA, while its 1999 figures estimate what proportion of what has happened can be attributed to NAFTA. Table 3 presents ERS estimated and predicted impacts of NAFTA for some commodities. In 1993, ERS predicted that NAFTA would have small impacts on U.S./Canada trade. However, in 1999, ERS estimated that NAFTA had medium (+++) and large effects on vegetable oil, cotton, wheat and wheat products, fresh and processed tomatoes, beef and veal exports to Canada. ERS also estimated that NAFTA had medium to large impacts on imports from Canada in beef and veal, fresh and process potatoes, and cattle and calves (negative).

Both imports (from western Canada) and exports (to Eastern Canada) in beef and veal increased between the two countries, a phenomenon that could not have been predicted from modeling efforts because models cannot handle imports and exports of the same product. Exports of fresh and processed tomatoes to the U.S. from both countries were attributed to NAFTA. Industry predictions were also wrong on some commodities. The National Pork Producer Council had predicted 400 mt increased in U.S. pork exports, but in fact, pork exports increased only 146 mt (NPPC, 1993). The California Tomato Board had predicted 10 mt more export of tomatoes, but instead tomato exports had drastically decreased by 1995.

Predictions that appear to be least accurate in hindsight were those that predicted increased prices and farm income and subsequent reduction of government transfer for most commodities. In contrast to these predictions, world commodity prices have decreased and farm income decrease. Since 1998, the U.S. has dramatically increased its emergency assistance payments to farmers. For example, in crop year 2001, the U.S. provided \$5.5 billion of economic assistance to farmers, \$4.6 billion of which were paid in supplemental market loss payments for program crop farmers. The maximum loan deficiency payment was also increased. In 2000, \$5.5 billion was provided in marketing loss assistance. In 1999, the emergency and market loss assistance provided \$5.9 billion

of emergency assistance. Similarly, the Canadian government had predicted net income increase (Agriculture and Agri-Food Canada, 2001). However, although Canadian exports increased, Canadian farm income decreased over the same period and farm debts are rising.

Models parameterized with historical data (i.e. *ex post*) are usually required for *ex ante* policy evaluation (Carlson et al., 1993, p. 155). Based on this fact, Carlson et al. (1993) suggest that *ex post* analyses of policies should be performed to improve the accuracy of *ex ante* analyses. They deplore however, that such *ex post* analyses are rare in the field of resource economics (including agriculture). For example, Baumel (2001) reports that USDA models consistently underestimate world food supply, and that these models consistently predict grain export increases, despite a continuous decline in these exports since their peak in 1980. The comparison of pre-NAFTA predictions to post-NAFTA statistics presented above shows that although commodity exports to Mexico closely match expected effects, export and imports from Canada were larger than expected, and price and revenue effects were generally wrong.

Of course, attributing trade changes to NAFTA is complicated because the GATT UR implementations started shortly after NAFTA in August 1995. The OECD has attempted to assess the impact of the UR in OECD countries and concluded that although the immediate quantitative effects of UR were difficult to distinguish from other national policies (e.g., the Farm Bill in 1996) and from bilateral and other multilateral agreements, the overall impact of the UR was thought to be limited. This limited impact is due to the weakness of its measures and the historically high level of support from which reductions were to be made.

Table 3. Comparison of ERS estimates of *ex ante* and *ex post* effects of NAFTA

	U.S. exports to		U.S. imports from	
	Canada	Mexico	Canada	Mexico
Corn [r]	+/0 ¹	+/***	+	
Sorghum [r]		++		
Wheat/wheat products [r]	++	+/***	+	
Oilseeds [r]	0	+/***	-	
Vegetable oils	++	+++/**	+	
Cattle and calves [r]	0	++++/***	---	+/**
Beef and veal [r]	++++	+++/**	++++	
Hogs [r]		+/***	0	
Pork [r]	+	+++/**	0	
Poultry meats	+	+/**	+	
Dairy products [r]	0	++++/**	0	0
Cotton	+++/*	+++/*		0
Sugar	0	0	0	++++/?
Fresh tomatoes	+++		+++	+++/**
Processed tomatoes [r]	++++	*		+++/**
Fresh and proc. Potatoes	+	+	+++	
Orange juice		++		++
Pear [r]	0	++++/***	0	
Apples [r]	0	++++/***	0	
Pears [r]	0	++++/***		
Grapes	0	+		0
Cantaloupe	0			+++

¹In this table, the '+' symbols indicate *ex ante* predictions of effects attributed to NAFTA by ERS (1993), and the '*' symbols indicate ERS (1999) predictions attributed to NAFTA after 10 years (2004). The number of symbols indicates the magnitude of the prediction. Specifically:

+ is less than 2% higher than without NAFTA,

++ is 2-5% higher than without NAFTA,

+++ is 6-15% higher than without NAFTA,

++++ is >15 2% higher than without NAFTA,

- is less than 2% higher than without NAFTA,

-- is 2-5% higher than without NAFTA,

--- is 6-15% higher than without NAFTA,

---- is >15 2% higher than without NAFTA,

* is less than 2% higher than without NAFTA,

** is 2-5% higher than without NAFTA,

*** is 6-15% higher than without NAFTA,

**** is >15 2% higher than without NAFTA,

[r] means that higher prices and revenues were expected for that sector in the U.S.

EX ante and ex post analysis of environmental effects of NAFTA

Turning to assessments of the potential environmental impacts of NAFTA, *ex ante* predictions about the environmental impacts of NAFTA were rare. DeJanvry, Sadoulet, & Davis (1997) argue that the intersection between NAFTA, the environment, and agriculture has received little attention or analysis because farm groups have largely focused on trade issues while environmental organizations have emphasized industrial and border pollution issues. The debate about agriculture has largely been limited to the use of pesticides and other chemicals in Mexico. DeJanvry and colleagues argue that, contrary to popular belief, there is little evidence for heavier pesticide use in Mexico following NAFTA. For example, they point to the fact that pesticide use for crops produced in Florida is often higher than that used in Mexico for the same crops.

The U.S. White House (Office of the President of the U.S, 1994) issued a report that used previous economic predictions of NAFTA effects to speculate on possible environmental impacts (no modeling is reported). The report predicts that the impact of increased grain, oilseed, and meat exports from the U.S. to Mexico and of fruits and vegetables from Mexico to the U.S. would vary regionally, depending on input mix and land-use patterns. Chemical use impacts were expected to vary regionally but the net impact was not clear *a priori*.

The environmental impacts of increase in U.S. output mentioned above is predicted to be small, because the Mexican market represents a small share of U.S. exports of these commodities. However, because the U.S. represents a large share of both the import and export markets for Mexico, the impacts in Mexico were expected to be to be more significant. NAFTA was not expected to change the structure or concentration of the North American agriculture, but to expand it. The report concluded that environmental impacts would depend on input and output changes, not on growth in trade.

Although transport was expected to increase, NAFTA provisions designed to offset these impacts (such as opening up cross-border trucking and risky transfer of hazardous cargoes at the border) were expected to minimize these impacts. A small increase in

overall chemical use in the U.S. was predicted, especially in corn (susceptible to pesticide and nitrate contamination) and wheat producing states (less susceptible), despite predicted net decrease in chemical use in California, Arizona, and Florida (this latter is very susceptible to contamination of groundwater) due to decrease fruit and vegetable production. The report noted the possibility that land would switch from corn or sorghum production into pasture areas to meet forecasted increased in beef production. However, pastureland might also encroach into forested areas, which would have more dramatic impacts. In Mexico, NAFTA was expected to increase wages and jobs for landless Mexican workers, forestalling cultivation of more marginalized land that would otherwise be cultivated.

Fruit and vegetable prices received by Mexican farmers were expected to rise, meat producers were expected to pay less for feed, and Mexican corn and sorghum producers were expected to face a decrease in prices. Changes in investment rules could be expected to encourage regional shifts in agricultural processing, which may in turn contribute to surface and groundwater pollution. The potential for the Canadian stumpage fees in BC to injure the U.S. forestry industry was also of concern. The report noted that the environmental agreement's procedure might encourage reassessment the pricing of forest resources. Implicitly, the Kuznet Curve Hypothesis was accepted in this report. Growth in GDP per capita in the long run was expected to have positive impacts on the environment, though some negative short-term impacts were also thought to be possible.

Two CEC studies show that cross-border transport of hazardous waste has increased significantly following NAFTA, and that transport corridors have become a major environmental problem (CEC, forthcoming). In part because NAFTA was supposed to remove the need to transfer cargo at the border, the U.S. still has not lifted the ban on Mexican trucks on its territory. The predicted 12 million trucks crossing the border by 2000 will bring increased emissions and noise. A possibility that Mexico's truck standard for air pollution be harmonized with the U.S. would mean that increased pollution would only come from increased traffic. The aforementioned report omits to mention that sugar tariffs have been retained and are thought to result in large environmental footprint in Florida. It is also interesting, that the report concluded that the environmental costs in Canada and U.S. following the NAFTA would be small, but that they could be high in Mexico due to the recent changes in land tenure laws and corn support payments. However, these changes became necessary for Mexico to join the GATT and NAFTA as evidenced in the World Bank's report of 1992. The implied relationship between GDP per capita and environmental quality in the agricultural sector has not been tested and is not clear from current indicators (see CEC Forthcoming 2002) for a details North American State of the Environment.

MODELING TRADE LIBERALIZATION IMPACTS ON AGRICULTURE

Economic models have been used widely to assess the impact of agricultural trade liberalization on countries' agriculture sectors. Starting with NAFTA, CGE models have been used to evaluate the effect of negotiated positions (ERS, 1998). There are

advantages in using global, economy-wide approaches that make explicit the assumed source of economic growth, that ensure countries can only import what they can afford, and that include intersectoral linkages and changes accompanying economic development (Strutt and Anderson, 1999). CGE models help quantify the magnitude of changes predicted by economic and trade theories, and, in the case of regional trade agreements, may be the only source of information about possible changes, since theory is ambiguous about net effects. Impacts are predicted based on the linkages between agricultural sectors or between agricultural and other sectors in the economy, and assumptions are made about how these sectors are linked. The difficulties of modeling these impacts increase with the degree of disaggregation, and, for this reason, most modeling work predicts aggregate-level impacts rather than impacts at the subsector agricultural level.

Theoretical models

Models are built to represent trade theory. Trade theory in turn predicts that removing government support programs in one or more countries could have multiple effects. First, if production has been subsidized more than is efficient, removing those subsidies would reduce production in the country. If this country is a net exporter, the world price that was previously depressed by this oversupply would subsequently increase, and exports would decrease. If all countries removed their support programs, foreign demand would also increase (if other countries were also overproducing), and world prices would further increase. At that new world price, domestic production would increase. This scenario must be modeled to identify winning and losing sectors, given that trade theory predicts that winners will gain more than losers will lose, but does not predict who will lose and whether they should be compensated. This analysis generally applies to the simple case of a single sector—for example, grains. However, once support for grains is removed and production decreases, resources such as land, capital, and labor that were used in that sector would likely be used by another sector. Therefore, other sectors also need to be modeled to predict which sector would most likely attract these resources.

The modeling approaches described above assume that subsidies were based on a per-unit measure of production. However, following the GATT negotiations, direct payments and support prices have been replaced by decoupled payments. Economic theory predicts that decoupled payments will be less trade distorting, but the effects of these payments on each commodity are more difficult to model. Land set-aside programs such as the U.S. Conservation Reserve Program (CRP), taking 7 million hectares out of production in 1997, have the largest potential to affect trade (Ervin, 2001). Inaccurate predictions of how many of these hectares will be brought back under various domestic or trade liberalization policies will bias estimated world prices. Haley, Herlihy, and Johnston (1991) suggested strategies for using SMOPSIM to model the effect of the U.S. CRP effects.

The approaches described above also assume that subsidies for inputs (such as water prices and fertilizers) were also removed and that the agricultural sector does not produce environmental externalities. If agriculture produces water pollution, air pollution, and/or soil erosion, a move is made from one inefficient outcome to another. It is not known *a priori* whether this move is welfare-enhancing, given that removing some distortions in a distorted world is not necessarily welfare-enhancing. Environmental market failure

means that removal of agricultural support policies will not be sufficient to achieve efficiency.

Reducing production will also have direct, indirect, and potentially multiplier effects along the chain of production. The magnitude of the social or welfare change of these changes in production generally depends on the level of tariffs in place prior to the agreement, on the elasticity of supply and demand in the home country, and on the difference in domestic and import price (Liapis et al. 1991).

Modeling of agricultural trade liberalization impacts in the NAFTA countries is generally done by the agricultural agencies of each country or by academia and international organizations. In some cases, additional modeling is done by a consortium of these institutions, such as the International Agricultural Trade Research Consortium in North America (IATRC). The models most commonly used to model agricultural trade liberalization are reviewed below.

Empirical models

Models used to measure the impacts of trade liberalization include SWOPSIM, a partial equilibrium model, developed by Roningen and Dixit at ERS (Roningen and Dixit, 1989) and used by Liapis, Krissof and Neff in 1991. This model uses a 1988 baseline to model trade liberalization between U.S. and Mexico within the scope of NAFTA. USDA/ERS also uses a CGE of the U.S. economy. Another model widely used is the OECD/MTM (Ministerial trade model) used by Tyer and Anderson (1987) and Anderson and Tyer (1991). Canada and many other countries use Aglink (these models are described in Appendix B).

In 1991, Grennes et al. presented a comparison of existing models being used to model trade liberalization. Some of these models focused on agriculture. Brown, Deardorff, and Stern (1991) modeled the three NAFTA countries in detail. Three models, one by the U.S. Department of Labor (Almon, et al. 1991), one by Hinojosa-Ojade et al. (1991), and one by KPG (1991) model the U.S. and Mexico explicitly. Cox and Harris (1991) is a Canadian macroeconomic model, the Sobarzo (1991) is a Mexican model, and USITC is a U.S. macroeconomic model. None of these model NAFTA effects exactly because exact measures and their implementation data were not known at the time.

Despite the differences in these models (see section below), all models except for the Labor Department model predict higher income with either bilateral or trilateral trade liberalization. While the USITC model describes changes as significant, moderate, or negligible, all other models present results of changes in real income and total trade.

The major disagreement among results predicted by these models is the impact on U.S. agriculture. The Labor Department model shows agriculture as one of the largest gainers in production and employment. In contrast, models by Brown, Deardorff, and Stern (1991), in which agriculture is a single sector in the model, and by KPG (1991), in which agriculture is divided into 4 sectors, show a contraction in agriculture following trade liberalization. USITC predicts large imports of fresh and processed horticultural products

to the U.S. from Mexico, but large exports of grains and oilseed from the U.S. to Mexico. Hinojosa-Ojade et al. (1991) use a CGE model with 7 sectors, one of which is agriculture, and three countries, the U.S., Mexico, and the rest of the world. Liapis et al. (1991) predict greater growth in U.S. agricultural exports to Mexico than in exports from Mexico to the U.S., because the initial 1988 border protection was higher in Mexico than in the U.S.. Of course, a slight rise in world prices is predicted. Welfare gains for U.S. producers, welfare losses for U.S. consumers, and reduced government expenditures on farm programs is predicted. Trade expansion from the U.S. to Mexico will result from an expansion of trade in feed grain, oilseed, live animals, meats, and dairy products. Mexico's export of horticultural product would account for half of the agricultural export expansion. Hanh et al. (1990) predict similar results, including small changes in North American prices and production but a greater impact on trade, especially grain-fed. The EC will cease leading beef exports and become an important importer of fed beef. .

Anderson and Tyer (1991) used a dynamic PEM model to assess the impact of significantly reducing developed world's agricultural subsidies. This model predicted lower farm gate prices, output, and exports, while the only thing that increased was price variability. This report, along with one by Goldin et al. (1993), also predicted large economic gains from trade liberalization. However, models by Francois et al. (1995) and Harrison et al (1995) predicted low economic gains, around 0.2 % of GDP growth. FAO (1995) also found only a small impact of the UR. Lankoski (1997) points to the difference in models, base years, and elasticities to explain the different results, but also points to the fact that these models assumed greater trade liberalizations than were actually enacted with the GATT UR or NAFTA.

At the beginning of the GATT talks, four different models yielded similar conclusions (specifically, (1) SWOPSIM based on 1986 conditions, Tyer and Anderson, 1987, Australia; (2) the OECD/MTM trade model; (3) International Institute of Applied System Analysis, Parikh et al., 1986, based on 1979-81; (4) the USDA/ERS CGE of the U.S. economy). Specifically, these models predicted that trade liberalization would increase beef prices and production, as well as net exports in Australia, New Zealand, the U.S., and South America (Hahn et al., 1990). Prices and production were predicted to decline in all of Europe and Japan, and net imports to increase.

Estimates of the economic impacts of agricultural trade liberalization have also relied on the Global Trade Analysis Model (GTAP), which is housed at Purdue University (Hertel, 1997). Simulations using the GTAP model, based on an assumption that any post-Uruguay Round trade distortions are removed, showed that agricultural liberalization would account for 40 per cent of developing countries' total gains from goods trade liberalization (Hertel *et al.*, 1999; Hockman and Anderson, 2000). Similar estimates of an overall positive economic impact are found in other modeling studies (European Commission, 1999; ADFAT, 1999). The distribution of this gain varies between developing countries, regions, and groups (e.g., agricultural exporters vs. food importers).

Another study reports positive findings of complete trade liberalization using GTAP. Nagarajan used a GTAP modeling system to predict the likely economic consequences of

complete trade liberalization in the agricultural and industrial and service sectors. Economic welfare gains were predicted in all regions, with the highest predictions made for the Asian region and the lowest predictions for the Africa region. However, the study also concludes that impacts will vary within regions (for example, between agricultural exporting and importing countries).

Reasons for discrepancies

In their review of different models used to measure the impacts of trade liberalization, Grennes et al (1991) found the following differences in analytic approaches in addition to country coverage: (1) model structure, (2) parameters used, (3) base year, (4) level of aggregation and definition of agricultural sectors, (5) assumptions concerning macroeconomic and exchange rate policies and changes in total employment and in real wages, (6) treatment of capital flow into Mexico, and more importantly (7) coverage and measurement of non-tariff trade barriers and the extent of trade liberalization.

Modeling economic impacts of agricultural trade liberalization is difficult for many reasons, including estimating commodity price supports equivalent, their indirect effects such as when they are capitalized into land value (which may result in further intensification as land value increases), set-aside land (for which the rules changed with the 1996 FAIR act in the U.S.), and a variety of trade and domestic measures that must often be changed following trade agreements (which may result in changes in crop mix, input use, technological change, and domestic and foreign investments). For instance, to model liberalization in milk trade, three factors must be assumed (changed): within and over-quota tariffs (this two-tiered tariff causes nonlinearity with the implied modeling difficulties), minimum access, and export subsidies. Estimating supports is not straightforward, resulting in controversy about the adequacy of the PSE measures (de Gorter and Harvey, 1990).

Deficient Models

Computable General Equilibrium (CGE) models examine the economy as a whole, including savings, employment, and income effects and intersectoral linkages. However, CGE models are less detailed because they aggregate many commodities and policies (Golden and Knudsen, 1990). The major criticisms of CGE models are that they are oversimplified given the number of countries, the number of commodities, and the diverse national policies involved in agricultural trade. For example, commodities are treated as homogenous, while there are many commodities within a country (e.g., grades of milk or beef; Hanh et al. 1990; Meilke and Lariviere, 1999). Also, often short or medium term elasticities and static long run frameworks are used together. Most CGE models assume perfect competition, though monopolistic competition could also portray the role of scale economies and product diversity increasingly present in the North American economy (Gunther and Upsprung, 2001). Scale economies give rise to uncompetitive markets and international intra-industry trade (in other words, to market power and/or profit). Programming models are often recommended and used at smaller to model resource policy, but they require an immense amount of data (Carlson et al. 1993).

Most agricultural trade liberalization models are partial equilibrium models (Lankoski, 1997). Partial equilibrium models (PEM) assess the impact of changes in agricultural

policies on specific agricultural commodities with the remaining sectors of the economy unchanged (Liapis et al. 1991). These models focus on efficiency gains within a sector, assuming that income, relative prices, and indirect efficiency gains remain constant. PEMs provide richer commodity and policy coverage, but do not account for intersectoral effects.

Most models, even partial equilibrium models, lack spatial components and do not distinguish between primary inputs and intermediary and final outputs. For example, the importance of a lack of spatial modeling is exemplified by the increased North-South movement of goods such as beef between Quebec and New York. This cross-border trade occurs because of the geographic proximity in these regions, in comparison to the distance between Quebec and, for example, British Columbia. Increased trade between Quebec and New York could not be picked up by the models, which thus underestimated the impact of trade liberalization. For another example, cattle are increasingly being fed in Canada and Mexico but slaughtered in the U.S.. Additionally, in processing, food-processing plants in Canada were relatively small to meet the need of a 30 million population while the U.S. food processing plants were large to meet their 250 million population. Following NAFTA, mass food processing moved to the U.S. and niche food processing moved to the smaller plants in Canada. Most models could not pick up this type of rationalization because they do not account for investment and the synergy between trade and Foreign Direct Investment (FDI). Finally, partial and general equilibrium models could not model the processing of products containing large amount of sugar that are pre-processed in the U.S., sent to Canada to finish the processing that includes the sugar, and then re-exported to the U.S.. Re-exportation is not possible in most models, nor is the exporting and importing of the same commodities by a country (as is the case for beef and veal between the U.S. and Canada).

In addition, trade restrictions that do remain in place following trade liberalization agreements are often more complex than pre-liberalization restrictions (OECD, 2001). These restrictions are country and product specific and hard to account for in world models.

A final modeling difficulty can be lack of data. Original data, such as elasticities of substitutions, are not often generated because it requires running large sets of econometric equations and collecting large amount of data. For example, elasticity estimates for SWOPSIM simulation in 1991 came from 6 different sources ranging from 1980 to 1990, and elasticity of substitution was assumed to be three and constant across commodities and countries (Liapis, et al. 1991).

Compliance with the agreement

Most participating countries are meeting their UR commitments (ERS, 1998). However, support for domestic policies considered to have the least effect on production (green box policies) have generally increased from their 1998-00 levels. With world prices as depressed as they are now, even countries that had banked some unused support for their farmers for later use may now not be able to meet their reduction commitments. Similarly, discrepancies may also arise when, as in the case of Mexico, negotiated tariff-

bases quotas are not applied for imported quantities above the quota, such as in the case of corn and poultry imported to Mexico.

Modeling Environmental Impact of Agricultural Trade Liberalization

Agriculture relies on large land areas and water resources and thus affects a greater share of nations' natural resources than other industries (Ervin, 2001). There is a clear need to identify areas and sectors where negative impacts can be foreseen and to put into place environmental policies to accompany trade agreements, because agricultural policy reform and trade liberalization are necessary but not sufficient to induce sustainable trade (Lankoski, 1997). For that reason, *ex ante* modeling of agricultural trade liberalization impacts on agriculture is important. The problem is that production is most likely to move to developing countries, and these countries have the least developed demand for environmental policies and the least capacity to enforce them (Ervin, 2001). Lankoski (1997) argues that increases in income could lead farmers to adopt more environmentally friendly production techniques. However, the Kuznet relationship between income per capita growth and improvement in environmental quality cannot be assumed to hold in industries that rely on natural resources or resource stocks that have stock feedback effects, such as forests, soil depth, and water.³ In these industries, economic growth may lead to overexploitation or pollution of resources beyond their regenerative or assimilative capacity (Anderson, 1994; ERS, 1996; Lankoski, 1997; Nagarajan) as exemplified by excess withdrawal in the Ogallala aquifer. Although the World Bank (1992) does report that many countries have already experienced improved air quality and increases in forested areas and protected habitats, ERS (1996) warns that more reliable data and studies are needed to understand the linkages between freer agricultural trade and the environment.

Though it is increasing, there is little empirical work that estimates, *ex ante*, the effects of agricultural trade liberalization on the environment (Lankoski, 1997). Increased trade flows of agricultural commodities have direct environmental effects through transportation and potential migration of harmful species. However, most environmental effects are indirect and result from complex changes in location, intensity, product-mix, and technology of agricultural production. All of these changes depend on how world relative prices change following trade liberalization (Lankoski, 1997), a phenomenon that must be modeled using CGE models.

In the short run, relative prices affect fertilizer, pesticides, and irrigation use. In the long run, adjustments affect land use and production technologies through price and income changes (Lankoski, 1997). Analyses of these indirect environmental impacts must narrow down to the farm and regional level to see how farmers respond to these changes in relative prices (Lankoski, 1997; Ervin, 2001). Increases in fertilizer and pesticide use and use of irrigation water do not necessarily imply more pollution. Actual environmental impacts will be determined by specific local factors such as whether farmers respond by

³ The hypothesis that environmental policy and quality will improve after the per capita income passes a given threshold seem to be empirically sound in the case of air pollution (Grossman and Krueger, 1991; Antle and HeideBrink, 1995)

changing the intensity of production (intensification) or area produced (extensification) and by the susceptibility or carrying capacity of production areas (leaching and runoff potential, soils erodability, salinity potential, etc.). Environmental damages also depend on the initial level of use and pollution of these resources. Thus, changes in practices and land uses must be geo-referenced or geographically specific to infer ambient environmental impacts. Given that CGE models are not disaggregated enough to account for this level of detail, partial equilibrium or sector models must be used. Even then, given the diffuse and stochastic nature of these pollutants, the environmental effects are uncertain (Antle and Just, 1991) and their effects may only appear after many years when long-term accumulation affects the resource's functioning and is thus detectable (Ervin, 2001).⁴

Theoretical models

Whether a free trade agreement is welfare-enhancing or not cannot be known *a priori*, because this prediction deals with suboptimal situations where the "theory of second best" applies (Liapis et al. 1991). Anderson (1991) has suggested that world food supply is relatively inelastic—in other words, that total food production would change only slightly following trade liberalization—and therefore suggests that preliminary examination of environmental impacts should start by examining where the volume of production will increase and where it will decrease. Generally, agricultural trade liberalization is believed to have a positive impact on the environment of developed countries but a negative effect in developing countries, due to increased production intensity and area. For example, Anderson suggests that a net reduction of chemical use in developed countries would be likely to more than offset expected increased use in developing countries, resulting in a net decrease in chemical use worldwide. However, the net welfare (and equity) effects of this shift have not been not estimated (Anderson, 1991).

Because developing countries have relatively large agricultural sectors (proportional to the total economy), agricultural trade liberalization may lead to widespread change throughout those countries (Anderson, 1994, Ervin, 2001). Anderson (1992) found that, as long as negative environmental externalities are internalized through environmental policies, freer trade will improve welfare. Lopez found a similar conclusion, but unlike Anderson, also found that without internalizing externalities, environmental effects were unambiguously negative following freer trade. In poorer countries, Lopez demonstrated that freer trade increases incentives to clear forested land and produce in marginal areas. Pethig (1976) also found that countries exporting pollution-intensive goods (not specific to agriculture) may or not be better off after liberalization, because higher pollution may offset traditional benefits from trade. In contrast to results found under perfect competition, countries dealing with imperfect competition in large open economies may have an incentive to relax environmental policies (Gunther and Upsprung, 2001). In the case of oligopolies or firms that compete in prices, environmental standards may also be

⁴ These changes are also affected by domestic agricultural policies. For instance, price supports encourage higher use of commercial fertilizers and chemicals (Lankoski, 1997). Even with trade liberalization, environmental impacts would be expected because of externalities if agricultural prices do not reflect environmental costs.

too strict. Gunther and Upsprung's (2001) review of the literature also demonstrates that in the case of transboundary pollution, trade liberalization may decrease welfare in the country with high environmental preferences. If capital is mobile, however, their results suggest that a polluting industry will move away from environmentally strict countries (Gunter et al, 2001). Their empirical review shows mixed results, although generally they find environmental costs are too small to affect trade. They find no clear indication that world economic integration can have either positive or negative impact on environmental policy and quality.

There seems to be a contrary predictions, however, regarding the effects of these policies. On the one hand, subsidized prices in developed countries are thought to lead to intensification and environmental problems, because most agricultural protection in OECD countries has traditionally taken the form of price support (often accompanied by quotas). The logic goes that removing this support through trade liberalization could be expected to reduce the use of pesticides and fertilizers, the conversion of environmentally sensitive areas, and withdrawals of irrigation water (Ervin, 1996). However, in developing countries, *low* prices are usually blamed for environmental degradation because they induce extensive production into marginal areas. In addition, contraction in agricultural production in developed countries is expected to reduce amenity value of some landscapes (Lankoski, 1997).

According to Carr et al. (1998) subsidy reduction has an output substitution impact, an output price impact, and an input substitution impact. Output impacts include, for example, shifts from program to non-program crops. It is of course important to determine which crops are involved, and how pollution intensive they are. Environmental impacts will then depend on the relative cleanliness of each crop. Lower output prices reduce the marginal product of input, thus leading to a reduction in intensity of production and inputs used, reducing environmental impacts. New Zealand's example is often cited as an empirical evidence of decreasing input use and intensity of agriculture when price supports are removed. Similarly, the Indonesian removal of pesticide subsidies led to government savings and a shift to integrated pest management (Lankoski, 1997). The modeled effects were underestimated (Ervin, 2001) because short-term economic analyses often underestimate the responsiveness of agricultural systems. Ervin provides many references documenting reduced incentives to use fertilizers and pesticides, to convert vulnerable land to production, or to use irrigation water following reduction, decoupling, or elimination of national production policies. When assessing the overall impact of these changes, the products that are encouraged and those that are discouraged are important since the final output mix is important as well (Lankoski, 1997). For instance, a study by Lojenga (1995 cited in Lankoski, 1997) in Costa Rica concluded that a structural adjustment merely reallocated environmental degradation from soil erosion to agrochemical pollution. Abler and Shortle (1992) concluded that removal of complete U.S. and EU agricultural support programs would result in significant growth in U.S. production and chemical use. Burfisher et al. (1992) find modest regional production increases. The expansion of horticultural exports from Kenya, for example, as a result of improved market access to the EU, increased significantly the negative environmental impact (Markandya *et al.*, 1999).

More empirical work is needed to shed light on what economic, social and environmental factors ensure that intensification of production will lead to reduced pressure off the remaining areas and vice versa.

Empirical models

As mentioned earlier, negotiations to include agriculture in GATT occurred in 1986. The first literature on *ex ante* economic impacts of agricultural trade liberalization appeared in 1991 (Krissof et al. 1990; Anderson, 1991; Anderson and Tyers, 1991) and 1992 (Anderson, 1992; Lutz, 1992). Initially (and still now to a certain extent), economic implications of trade liberalization were used to infer possible environmental impacts instead of using explicit modeling (Lankoski, 1997). It is not until 1994 that economic results were linked to environmental indicators to predict the environmental impacts of agricultural trade liberalization (see for example Anderson, 1994; Anderson and Strutt, 1996; Figueroa et al. 1996). No references were found that model the potential environmental impacts of NAFTA's agricultural measures.

Modeling studies have been concerned mainly with estimating economic welfare impacts (Hertel, 1997; Hockman and Anderson, 2000; Matthews, 2000). Certain of the environmental impacts of trade liberalization have also been estimated using this modeling approach (Anderson and Strutt, 1996; Dean, 1999; OECD, 2000). The most commonly used approach has been to assume a functional relationship between the outputs of particular activities and environmental externalities, using information from ecological or biological systems modeling to link output changes to environmental impact. For example, OECD's Aglink model and the Agro-environmental indicators database have been linked to derive quantitative estimates of the impact of trade liberalization on the environment (OECD, 2000; OECD, 2001). OECD (2000, 2001) notes, however, that "...numerical results have to be interpreted with care, since the relationship between agriculture, trade and the environment is complex, depending on such location-specific and often scientifically not fully explored factors like the assimilative capacity of the natural environment" (OECD, 2000: 10). This point is echoed by Ervin (2000), who acknowledges the progress that has been made over the past decade in building methodologies, but also points to the need for further theoretical and empirical developments to reliably describe the time path of complex changes.

Using a partial equilibrium model, Anderson (1992) predicts that world food production and prices would change little with multilateral trade liberalization, because production growth in developed countries would offset production declines in developing countries. Anderson predicts that world chemical use would decline, because increased production in developing countries relies on increased labor instead of chemicals. He does not predict growth in deforestation, because he presumes land supply will be unresponsive to change in output price. He predicts that meat and milk products will be displaced to developing countries with a pasture-based livestock sector. Lutz (1990) predicts a reduction in environmental impacts in developed countries following an increase in world prices, with the opposite being true in developing countries. In addition, increased price volatility may induce a greater crop diversification. Reduction of corn and chemical

subsidies were expected to reduce cultivation of marginal lands, potential for erosion, deforestation, and loss of biodiversity.

Page and Davenport (1994), FAO (1995), Goldin and van der Mensbrugghe (1995) all predict modest price changes following the UR. These predictions suggest environmental effects due to price changes may be low. Anderson and Strutt (1996) and Ervin (1996) also predict small changes in the global relocation of production following complete trade liberalization of agriculture, though effects would be redistributed around the world (with more production in Africa, North America, Oceania and Latin America and less in Western Europe and Japan; FAO, 1995). However, it does not necessarily follow that environmental impacts will be small. For example, agricultural policy changes to adapt to the GATT may have positive or negative impacts. Whether redistribution will improve the global environmental condition or not will depend on whether increases in production will occur at the intensive or extensive margin, and where in each country these effects occur.

Anderson (1994) modeled the environmental impact of NAFTA on environmental quality in Mexico, and concluded that, although chemical use and irrigation may increase in fruit and vegetable sector, this effect may be offset by corresponding declines in the grain sector. He predicted that pastureland for increased livestock production will come from land previously in grain production, rather than from marginal land or forested areas.

Ex post analyses of the environmental impact of agricultural trade liberalization have not been conducted as far as the author knows. Ervin (2001) concludes from a review of the literature that no widespread losses have occurred with trade liberalization, neither to agricultural trade nor to the environment. Environmental problems are instead concentrated in specific crops or in specific areas, such as border zones. However, conflict may still arise because of ill-defined government policies and missing markets. Agriculture is still a source of water quality problems in the three countries, and further trade liberalization may increase or remove some of this pressure.

In summary, most models have estimated the effect of complete trade liberalization instead of the effects of specific agreements. Thus the effects will likely be different from those expected with partial liberalization resulting from political economy. However, significant environmental costs at the international and national levels can be expected with agricultural trade liberalization. At the international level, for example, the OECD study estimates a significant increase in methane emissions. At the domestic level, OECD's analysis suggests that environmental impacts may be expected from a fall in agricultural prices and production intensity, accompanied by reduced levels of fertilizer and pesticide application. Environmental impacts will also likely occur both in developing and developed countries. Aggregate level studies point to economic welfare gains from agricultural trade liberalization for developing countries as a whole, although countries will experience significant variation in the magnitude of the gain. However many potential impacts, such as impacts on biodiversity, soil and food protection, landscape, and marginal agricultural land, are still uncertain (OECD, 2001). The environmental consequences of trade liberalization will also depend on whether and

where production is increased at the intensive or the extensive margin. These decisions "depend directly on the incentives and disincentives created by agri-environmental policies" (Ervin, 1999: 69). The direction and magnitude of these changes will depend on producers' responses to trade liberalization policies, and on additional changes in agricultural production patterns, the state of the environment, and the environmental regulations and policies in place. Environmental impacts will vary, therefore, between countries, regions and locations. These are likely to be relatively more significant in developing countries where trade liberalization leads to an expansion in commercial production, and environmental regulatory frameworks are weaker.

Trade liberalization will not result in win-win outcomes on its own; instead, it must be accompanied by environmental policies to address potentially significant negative environmental and social impacts. Some studies conclude that if policies are put in place and enforced, *potential* win-win outcomes could result. However, bioeconomic models at various scales should be used to predict where larger environmental impacts may be expected to avoid the realization of these problems. No model currently exists to accurately model the environmental impact of agricultural trade liberalization.

Suggested Improvements

Based on the above review, and based on IPPC recommendations for land use cover change (LUCC) modeling (Turner, Skole, Sanderson, Fischer, Fresco, and Leemans, 2001), the following recommendations for models improvements should be considered.

Scale and Structure of Models

Large-scale modeling analyses do not capture the diversity of adjustment necessary to forecast environmental impacts (Ervin, 2001). Given complex adjustments in location, intensity, product-mix, and technology of agricultural production following trade liberalization (and domestic policy changes), bioeconomic models that include land use changes should be used to estimate environmental impacts.

Turner et al. (2001) suggest a number of modeling development strategies to improve the accuracy of bioeconomic models predicting land use cover change, and these recommendations may also apply here. Most importantly, they point out the need for regional and global models that represent a broader range of land uses at a more detailed geographical scale. These models should incorporate both biophysical and human drivers of land use change, and they should be able to make predictions over a time scale of 50-100 years (for GHG effects). Because this level of information is not currently available at the regional and national scales, using local data to inform and check larger scale models would be prudent until appropriate data is available. Turner and colleagues suggest that these models should be structured so that they can be both theoretically based, and yet flexible enough to permit integration of a variety of drivers of land use change, such as economic forces and technological change. These models should also incorporate ways to represent linkages "horizontally" between sectors and "vertically" through economic and physical levels.

Failing to model the overall general equilibrium effect of freer trade could yield erroneous environmental impact results (ERS, 1996). To provide adequate predictions of the environmental impacts of agricultural trade liberalization, new relative prices must be predicted at the international or national level. Responses of the sectors and subsectors by regions must subsequently be modeled. Since CGE models can find aggregate quantities and prices, their results should be made compatible and fed into more disaggregated, geographically-referenced models. However, existing CGE models should be upgraded to reflect the increasingly prominent scale effects in production and pollution (instead of assuming perfect competitive and fixed proportions between sectoral output and the emissions associated with that sector). For example, Beghin et al.(1999)⁵ exemplify an approach to modeling the relationships between trade and FDI and to modeling vertical integration in the agricultural sector.

Microeconomic or farm models must then be used to account for changes in soil, water quality, and biodiversity. However, these models lack multiple-country coverage and resulting price equilibria, and they do not account for intersectoral trade-offs (ERS, 1996). Mathematical programming models are often more adept to do these complicated relationships than partial or general equilibrium models (Carlson et al, 1993).

Changes in crop mix, input use, buying and selling of land, movements of labor and capital, and investment in new machinery as a result of price adjustment following trade liberalizations must thus be modeled at the regional level. Ervin (2000) argues that an “ideal” framework must identify dynamic shifts in production and input use and must include linkages to other sectors (such as transportation, voluntary private environmental management initiatives, public policy responses, and the role of R&D). In short, the ideal analysis should capture joint geo-spatial production and environmental relationships (Ervin, 2001).

Turner et al (2001) also recommend that bioeconomic models predicting land use cover change should incorporate water use. Agriculture is the principal consumer of water worldwide, and growing intensification of agriculture will only increase demand. Water supplies, distribution mechanisms, price, and policies will likely affect land use cover change. The IMPACT model, which assesses the effect of increased water competition between the U.S. municipalities and the agricultural sector, is one example of how this can be done.

Further, given that models are not useful unless they are accurate, Turner et al. (2001) recommend that efforts should be made to test the accuracy of LUCC models through sensitivity analysis and validation. Carlson et al. (1994) also argue for performing more *ex post* analyses and compared them to *ex ante* predictions to improve modeling capacity.

⁵ Beghin et al. (1999) adapted a Trade and Environment EQUILibrium Analysis (TEQUILA) model developed at the OECD Development Center to link economic outputs to pollution emissions at the intermediate and final consumption level for Mexico. The model is recursive, dynamic, and multi-sectoral, and it disaggregates natural resource-based sectors and their forward linkages to manufacturing.

Finally, bioeconomic models inevitably rely on a number of assumptions about future trends in socio-economic development. Turner et al. (2001) suggest that, given uncertainty regarding these trends, a number of scenarios should be developed to reflect plausible assumptions about possible socio-demographic and economic trends. These scenarios could also incorporate any possible recursive effects that long-term global environmental changes may have on land use. This recommendation could be implemented by building on previous trends work at the CEC. Given the similarities between LUCC and agricultural environmental impact modeling efforts, it may be productive for both of these research areas to work together in model development efforts.

Additional Missing Relationships

The ERS (1996) reminds us that that no single theoretical methodology can encompass all of the environmental implications of trade liberalization. In addition to recommendations made by the IPPC LUCC report (Turner et al., 2001), some other key relationships have been neglected in most analyses to date and thus provide opportunities for improving bioeconomic models.. These include linkages to non-agricultural sectors, indirect and second-round effects, and missing environmental markets.

Most modeling analyses are aggregate in scope. These aggregate analyses are sufficient to assess the impact of national policies, such as the CRP, but are insufficient to assess programs at sub-national levels. There is some evidence that agri-environmental policies are increasing in number and effect at the sub-national levels (e.g., state and local governments) in the U.S. (Brouwer et al., 1999). If accurate, the added environmental stresses caused by policy reform and trade liberalization may be dealt with by new sub-national policies to some degree. Hence, the modeling analyses will likely overestimate the environmental effects and underestimate the costs imposed on producers.

There is a growing appreciation that public policies must be augmented by private business approaches to achieve sustainable solutions to agri-environmental problems. An increasing number of farms and other agribusinesses are experimenting with new production processes that use systemic approaches to environmental management. Examples include precision applications of chemicals and water, crop rotations for biological pest control, and advanced composting processes for organic agriculture production. They are driven by compliance-push or consumer demand-pull forces, and may foretell the next generation of environmental management in agriculture.

Private environmental initiatives in agriculture appears on the rise. Antle theorizes that quality attributes will play an increasing role in agriculture. OECD (2001) has done some modeling of the effect of changes in consumer demand for more environmentally sound products. According to this perspective, farmers and agribusiness supply products with differentiable quality attributes, such as high lysine corn. The main economic driver of the increased demand for environmental quality is increasing personal income, reflecting a positive income elasticity. For example, demand for water quality and other environmental services tends to increase as incomes rise. A broadening segment of consumers and investors is also rewarding firms that supply competitively- priced

products that possess environmental qualities. The effects of the robust demand for environmental quality have been expressed mostly in the political arena via higher standards and new programs. But the influence is also increasingly surfacing in the market with firms supplying “green” products. The bottom line to these trends suggests that the values of a farm’s environmental effects are rising relative to those for food and fiber (Carpentier and Ervin, forthcoming).

In many cases, the solutions to agri-environmental problems will necessitate the development and diffusion of new production technologies (CEC, forthcoming 2002b). Analyses of the forces that drive new agricultural production, processing, and transport technology developments, and the roles of these technologies in environmental management, have been neglected. Human capital and management play crucial roles in shaping the adoption and implementation of those technologies. This topic is timely because the traditional roles of public and private research in leading the discovery and application of agricultural technologies have reversed in many OECD countries (Figure 8). Ervin and Schmitz (1996) show that when markets for environmental goods and services are missing or poorly functioning, we should not expect the technologies developed under private or public R&D systems to capture effectively full social costs.

In addition to the multilateral GATT UR, many other trade agreements have the potential to affect predictions (including the MERCOSUR agreement, 1995; the Andean Pact revived in 1990; the Central American Common Market, CACM, revived in 1990; and Chile’s numerous bilateral agreements with MERCOSUR, Mexico, 1992, Venezuela, 1993, Bolivia, 1993, Columbia, 1994, Ecuador, 1995, and Canada, 1997). These agreements were not included in the prediction models conducted in 1994 (Stout and Ugaz-Pereda, 1999). The agreement with Canada, for instance, is worrisome for the U.S. now that Canada faces more favorable tariffs for potatoes, wheat, and vegetable oils, commodities for which U.S. and Canada compete on the international market. Mexico is not part of MERCOSUR, but talks are underway between the entities (Stout and Ugaz-Pereda, 1999). The Andean pact and CACM have an escalating structure of tariffs that discourages exports of processed foods to these countries. The Andean Pact in effect also sets a floor on import prices for non-member countries for palm oil, soybean oil, rice, sugar, barley, milk, corn, soybeans, wheat, chicken, and pork – in effect, restricting non-member country exports to the region in times of falling prices. These effects have not been taken into account in previous modeling.

Lack of data

Modeling and assessment work is also limited by the lack of environmental data and corporate reporting. In addition to the lack of understanding of how economic activity affects physical variables, it is difficult to model local water and soil quality due to lack of physical data (ERS, 1996). The SWOPSIM model, which is parsimonious in the amount of data required, requires elasticity of demand for each good, consumption share of each product, and an elasticity of substitution among the products that comprise a good (Liapis et al. 1991).

Further environmental modeling assessment is also limited by the lack of corporate reporting. A November 2001 report of Corporate Sustainability Reporting in Canada reports the shocking finding that sectors such as agriculture and agri-food, pharmaceuticals, and manufacturing do **not** provide environmental, social, or sustainability reports (Stratos, 2001). Also governments do not collect and report environmental pollution control costs for agriculture as they do for other industries (Ervin, 2001). The report also finds poor environmental reporting for those who report on environmental issues. The report concludes that to convey a clear picture on their environmental performance, firms must move from reporting on energy use and a few regulated emissions to reporting full life cycle analysis, including suppliers and buyers. This will require developing performance indicators that reflect the triple bottom line of a company.

The government of Canada and OECD both have done considerable work on agro-environmental indicators (OECD, 2001; Agriculture and Agri-Food Canada, 2000). The OECD database links estimates of trade-induced changes in agricultural production to data on the state of the environment contained in the OECD's *Agri-environmental Indicators* (AEI) database, in order to aggregate environmental effects in physical terms across crops and/or livestock, such as in the form of nutrient balances or quantity of pesticide used. For example, the AEI database on nitrogen balances holds detailed information on the number of different livestock, the area and yield of different crops, and the amount of non-organic fertilizer, and the technical coefficients that link, for example, livestock numbers to the amount of nitrogen in animal waste or harvested crop quantities to N-uptake. These data can be used to project the environmental impact of trade-induced changes in agricultural production. Information is still missing, however, particularly regarding biodiversity. For instance, different environmental indicators cannot be aggregated to obtain an overall figure for the environmental impact of further agricultural trade liberalization under current methodology.

***Ex post* Analyses**

Multilateral agricultural trade liberalization has both potential domestic and international impacts. OECD (2000) identifies three international impacts -- transboundary spill-overs, transport, and introduction of harmful organisms -- and domestic impacts on pollution and environmental amenities. Examples of these impacts can be found in the NAFTA countries, but no comprehensive *ex post* analysis have been found that assess the environmental impacts of agricultural trade liberalization in North America.

For example, transboundary spill-overs include changes in agricultural practices that reduce or increase pesticide and fertilizer run-offs into rivers or lakes that flow or cross into another country (e.g., the Great Lakes and the Colorado and Mississippi rivers). These spill-over effects also include GHG and losses of plant and animal species that are endemic to countries. Transportation effects are clear in North America. Total traffic has increased 71 percent since NAFTA, from 2 million in 1994 to 3.2 million in 1998. The proportion of this increase in traffic growth that can be attributed to the agriculture sector is unknown, but is likely significant, because of the progressive tariff structure in place which, by charging tariffs for processed goods, encourage trade in raw, bulky

commodities. The Mexico-U.S.-Canada NAFTA trade corridor, particularly those traffic flows prompted by trade liberalization, is forecasted to continue to grow. Most transboundary problems (for example, negative impacts to atmosphere and oceans) affected by the transportation sector are not subject to multilateral effective control (Ervin, 2001). For example, removal of the grain transport subsidy by train in Canada may have removed East-West transport but have also increased North-South movement and movement in trucks. The net effects of these shifts in domestic programs to comply with trade agreements need to be carefully analyzed and accompanied by offsetting environmental policies when deemed necessary (Ervin, 2001). Because the transport sector and energy prices do not internalize all their costs, trade liberalization may exacerbate environmental damage from transport. For instance, Ervin reports a study by Whalley (1996) that shows that trade patterns would be significantly affected by a carbon tax, moving away from trade in bulk commodities and more towards processed commodities.

Introduction of harmful organisms is also a problem as new pathways are opened. OTA (1995) concluded that risks of harmful species entering the U.S. through trade were significant and that existing control was insufficient. It is difficult to identify whether trade was the source of many invasive species. The transfer of GMO into the wild, such as the case of Bt Corn in Mexico, is causing serious concerns for which solutions have not been thought of yet.

Implications of Further Liberalization

A new round of multilateral trade negotiations for agriculture that was initially scheduled to begin in 1999 has begun at the end of 2001. Relatively small changes in production and trade being predicted. According to projections from the *Aglink* model's baseline scenario, output of most agricultural commodities in the OECD in 2004 will be higher than average production during 1995 to 1997. The commodities with the strongest growth in the medium term are projected to be poultry and oilseeds. The widespread rise in agricultural production will likely lead to increased use of production-related inputs, such as fertilizers and pesticides. This expanded application of agro-chemicals might cause additional environmental stress, unless improvements in farm management practices or the development of more environmentally benign fertilizers and pesticides compensate for the higher levels of use. Thus, the effects of past liberalization should be assessed to inform the potential impacts of these further liberalizations.

References

[to be completed]

Ackerman, F., Gallagher, K. P., and Ney, L. 2001 (draft). *Environmental reviews of proposed trade agreements: Assessing the North American experience*. Study prepared for the North American Commission for Environmental Cooperation.

Agriculture and Agri-Food Canada. 1995. *Perspectives à moyen terme*. Ottawa, Ontario: Agriculture and Agri-Food Canada.

- Agriculture and Agri-Food Canada. 1995. *Perspectives à moyen terme*. Ottawa, Ontario: Agriculture and Agri-Food Canada.
- Agriculture and Agri-Food Canada. 1999. *Medium term policy baseline*. Ottawa, Ontario: Agriculture and Agri-Food Canada, Research and Analysis Directorate, Strategic Policy Branch.
- Agriculture and Agri-Food Canada. 2000. *Medium term policy baseline*. Ottawa, Ontario: Agriculture and Agri-Food Canada, Research and Analysis Directorate, Strategic Policy Branch.
- Agriculture and Agri-Food Canada. 2001. *Medium term policy baseline*. Ottawa, Ontario: AAFC.
- Agriculture and Agri-Food Canada. 2001. *Vertical Linkages in Agri-Food Supply Chains in Canada and the United States*. Ottawa, Ontario: Agriculture and Agri-Food Canada, Strategic Policy Branch.
- Alexandratos, N. 2000. *Outlook for agriculture and the environment*. Report prepared for the Organization for Economic Development and Cooperation's Environmental Directorate.
- Anderson, K & Strutt, A. 1996. On measuring the environmental impact of agricultural trade liberalization. In *Agriculture, Trade, and the Environment: Discovering and Measuring the Critical Linkages* (pp. 151-72), edited by M. E. Bredahl, N. Ballenger, J. C. Dunmore, and T. L. Roe. Boulder, Colo.: Westview Press.
- Turner, B.L., Skole, D., Sanderson, S., Fischer, G., Fresco, L., and Leemans, R. 2001. Focus 3: Regional and global models: Framework for integrative assessments. In *Land Use and Land Cover Change Science: Research Plan*. Available online: www.uni-bonn.de/ihdp/luccsp.htm
- International Energy Association. 1998. Overview of existing model structures. In *Mapping the Energy Future: Energy Modeling and Climate Change Policy* (Ch. 2). www.iea.org/pubs/studies/files/mappng/map/05-mapp.htm
- Barron, M. A. & Rello, F. 1999. The agro-industry and poverty, a positive link? The case of the tomato industry and its impact on poverty-stricken regions in Mexico. Paper presented at the workshop, "Agroindustrialization, globalization, and economic development, Aug 6-7 1999. Nashville, TN.
- Baruchello, R. R., Bivings, L., Carter, C., Josling, T., Lindsey, P., McCalla, A. 1991. *The implications of a North American Free Trade Area for Agriculture*. International Agriculture Trade Research Consortium Commissioned Paper Number 11. St. Paul, MN: University of Minnesota Department of Applied Economics.
- Bolling, C. H. 1998. U.S. foreign direct investment in the global processed food industries. In *Regional Trade Agreements and U.S. Agriculture*, Agricultural Economic Report Number 771, edited by M. E. Burfisher & E. A. Jones. Washington, DC: U. S. Department of Agriculture, Economic Research Service.
- Burfisher, M. E. & Jones, E. A. 1998. *Regional Trade Agreements and U. S. Agriculture: An Overview*. Agriculture Information Bulletin Number 745. Washington, DC: United States Department of Agriculture, Economic Research Service.

Burfisher, M. E. & Jones, E. A., Eds. 1998. *Regional Trade Agreements and U.S. agriculture*, Agricultural Economic Report Number 771. Washington, DC: U. S. Department of Agriculture, Economic Research Service,

Burfisher, M. E., Robinson, S., and Thierfelder, K. 1998. Farm policy reforms and harmonization in the NAFTA. In *Regional Trade Agreements and U.S. Agriculture*, Agricultural Economic Report Number 771, edited by M. E. Burfisher & E. A. Jones. Washington, DC: U. S. Department of Agriculture, Economic Research Service.

Burfisher, M.E., House, R.M., and Langley, S.V. 1992. Free trade impacts on U.S. and Southern agriculture. *Southern Journal of Agricultural Economics*, 24(1), 61-78.

Cameron, R. & Sydor, A. Is Mexico becoming a North American tiger? The battle for the U. S. Market. *Monthly Trade Bulletin*, 2 (9). Ottawa: Industry Canada Department of Foreign Affairs and international Trade.

Carlson, G. A., Zilberman, D. & Miranowski, J. A. 1993. *Agricultural and Environmental Resource Economics*. New York: Oxford University Press.

de Janvry, A., Sadoulet, E., & Davis, B. 1997. *NAFTA and agriculture: An early assessment*. California Agricultural Experiment Station Working Paper Number 807. Berkeley, CA: University of California at Berkeley.

Dean, J. M. 1999. Testing the impact of trade liberalization on the environment: Theory and evidence. In *Trade, Global Policy, and the Environment*, edited by P. G. Frederiksson. World Bank Discussion Paper Number 402. Washington, DC: The World Bank.

Diakosavvas, D. 2001. *The Uruguay Round Agreement on Agriculture in Practice: How Open are OECD Markets?* Paper presented at the World Bank Conference, Leveraging Trade, Global Market Integration, and the New WTO Negotiations for Development, 23-24 July, Washington, D.C..

Dixit, P, Josling, T., & Blandford, D. 2001. *The Current WTO Agricultural Negotiations: Options for Progress*. International Agricultural Trade Research Consortium Commissioned Paper Number 18. St. Paul, MN: University of Minnesota, Department of Applied Economics.

Economic Research Service. 1993. *Effects of the North American Free Trade Agreement on U. S. Agricultural Commodities*. Washington, DC: U. S. Department of Agriculture, Economic Research Service.

Economic Research Service. 1994. *Effects of the Uruguay Round Agreement on U.S. Agricultural Commodities*. Washington, DC: U. S. Department of Agriculture, Economic Research Service.

Economic Research Service. 2000. *NAFTA Commodity Supplement*. Report WRA-99-1A. Washington, DC: U.S. Department of Agriculture, Economic Research Service.

Economic Research Service. 2001. *Foreign Agriculture Trade of the United States (FATUS)*. <http://www.ers.usda.gov/data/FATUS/>

Ervin, D. E. & Keller, V. N. Key questions. In *Agriculture, Trade, and the Environment: Discovering and Measuring the Critical Linkages* (Ch. 17, pp. 281-294), edited by M. E. Bredahl, N. Ballenger, J. C. Dunmore, & T. L. Roe. Boulder, CO: Westview Press.

Garcia, R. & Graber, D. W. 1996. NAFTA's environmental effects: General connecting processes. NAFTA Effects Working Paper Number 6. Montreal, Canada: Commission for Environmental Cooperation.

Gopinath, M., Pick, D., and Vasavada, U. 1999. The economics of foreign direct investment and trade with an application to the U. S. food processing industry. *American Journal of Agricultural Economics*, 81(2), 442- 452.

Grennes, T., Estrada, J. H., Krissoff, B., Gardea, J. M., Sharples, J. & Valdes, C. 1991. *An Analysis of a United States-Canada-Mexico Free Trade Agreement*. International Agriculture Trade Research Consortium Commissioned Paper Number 10. St. Paul, MN: University of Minnesota, Department of Applied Economics.

Hahn, W. F., Crawford, T. L., Baily, L., & Shagam, S. 1990. *The World Beef Market: Government Intervention and Multilateral Policy Reform*. Washington, DC: United States Department of Agriculture, Economic Research Service.

Hazledine, T. 1992. *A Critique of Computable General Equilibrium Models for Trade Policy Analysis*. IATRC Working paper Number 92-4.

Industry Canada. 1999. *The Long and Short of the Canada-U.S. Free Trade Agreement. Perspectives on North American Free Trade*. Paper Number 2. Ottawa: Industry Canada.

Krissoff, B., Ballenger, N., Dunmore, J., & Gray, D. 1996. *Exploring Linkages among Agriculture, Trade, and the Environment: Issues for the Next Century*. Agricultural Economic Report Number 738. Washington, DC: U.S. Department of Agriculture, Economic Research Service.

Lankoski, J. 1997. *Environmental Effects of Agriculture Trade Liberalization and Domestic Agricultural Policy Reforms*. United Nations Conference on Trade and Development Discussion Paper Number 126.

Liapis, P. S., Krissoff, B., Neff, L. 1993. *Modeling Preferential Trading Arrangements for the Agricultural Sector: A U.S.-Mexico Example*. Washington, DC: U.S. Department of Agriculture, Economic Research Service.

Link, J. & Zahniser, S. (Eds.). 1999. *NAFTA: Situation and Outlook Series*. International Agriculture and Trade Reports, WRS-99-1. Washington, DC: U.S. Department of Agriculture, Economic Research Service.

Martin, L., Runge, C. F., & van Duren, E. Canada and the U.S.: Relative competitiveness of selected agri-food industries. *Canadian Journal of Agricultural Economics*, 38(4), 821-834.

McCarl, B., Nadya, W., and Houshmand, Z. 1994. *Environmental and Economic Effects of Trade and Agricultural Policy Alterations*. Washington, DC: U.S. Congress, Office of Technology Assessment.

- Meilke, K. & Lariviere, S. 1999. *The Problems and Pitfalls in Modeling International Dairy Trade Liberalization*. International Agricultural Trade Research Consortium Working Paper 99-3. Guelph, Ontario: University of Guelph, Department of Agricultural Economics and Business.
- Meilke, K., & van Duren, E. 1996. The North American Free Trade Agreement and the Canadian agri-food sector. *Canadian Journal of Agricultural Economics*, 44 (1), 19-37.
- Office of the President of the United States. 1994. *The NAFTA: Expanding U.S. Exports, Jobs, and Growth: Report on Environmental Issues*. Washington, DC: U.S. Government Printing Office.
- Organization for Economic Cooperation and Development. 1995. *Les Perspectives Agricoles 1995-2000*. Paris, France: OECD Publications.
- Organization for Economic Cooperation and Development. 1996. *Les Perspectives Agricoles: Tendances et Enjeux à l'Horizon 2000*. Paris, France: OECD Publications.
- Organization for Economic Cooperation and Development. 1997. *Les Perspectives agricoles*. Paris, France: OECD Publications.
- Organization for Economic Cooperation and Development. 1998. *Les Perspectives Agricoles 1998-2003*. Paris, France: OECD Publications.
- Organization for Economic Cooperation and Development. 2000. *Perspectives de l'OCDE 2000-2005*. Paris, France: OECD Publications.
- Organization for Economic Co-operation and Development. 2001. *Improving the Environmental Performance of Agriculture: Policy Options and Market Approaches*. Paris, France: OECD Publications.
- Organization for Economic Co-operation and Development. 2001. *Perspectives à Long Terme de l'Agriculture et de l'Environnement*. Paris, France: OECD Publications.
- Organization for Economic Development and Cooperation. 2001. OECD Agricultural Commodities Outlook Database. Ottawa, Ontario: Ivation Datasystems, Inc.
- Organization for Economic Development and Cooperation. 1999. *Perspectives Agricoles de l'OCDE: 1999-2004*. Paris, France: OECD Publications.
- Organization for Economic Development and Cooperation. 2001. *Environmental Indicators for Agriculture. Vol. 3: Methods and Results*. Paris, France: OECD Publications
- Runge, C. F. 1993. *The North American Free Trade Agreement (NAFTA): Issues and Impacts for Minnesota*. Working paper WP93-2. St. Paul, MN: University of Minnesota, Center for International Food and Agricultural Policy.
- Runge, C. F. (1993). What NAFTA will mean for Minnesota's economy. *Minnesota Agricultural Economist*, Number 674, 1.

- Schamel, G. & de Gorter, H. 2000. *More on Welfare Effects of Distortions via Environmental and Trade Policy*. Policy Discussion Paper Number 0013,. Adelaide, Australia: University of Adelaide, Centre for international Economic Studies
- Schulze, G. G. & Ursprung, H. W. 2001. *International Environmental Economics: A Survey of the Issues*. New York: Oxford University Press.
- Sheffield, S. 1998. Agriculture, GATT, and regional trade agreements. In *Regional Trade Agreements and U.S. Agriculture*, Agricultural Economic Report Number 771, edited by M. E. Burfisher & E. A. Jones. Washington, DC: U. S. Department of Agriculture, Economic Research Service.
- Stout, J. V. & Ugaz-Pereda, J. 1998. Western hemisphere trading blocs and tariff barriers for U.S. agricultural exports. In *Regional Trade Agreements and U.S. Agriculture*, Agricultural Economic Report Number 771, edited by M. E. Burfisher & E. A. Jones. Washington, DC: U. S. Department of Agriculture, Economic Research Service.
- Stratos, Inc. 2001. *Stepping Forward: Corporate Sustainability Reporting in Canada*. Ottawa, Ontario: Stratos.
- Tangermann, S., Honma, M., Josling, T., Lee, J., MacLaren, D., McClatchy, D., Miner, B., Pursell, G., Sumner, D., & Valdes, A. (1997). *Implementation of the Uruguay Round Agreement on Agriculture and Issues for the Next Round of Agricultural Negotiations*. International Agricultural Trade Research Consortium Commissioned Paper Number 12. St. Paul, MN: University of Minnesota, Department of Applied Economics.
- Taylor, R. et. Al.. 1993. *Agricultural Sector Models for the United States*. Ames: Iowa State University Press.
- Tweeten, L, Sharples, J., & Evers-Smith, L. 1996. Impact of CFTA/NAFTA on U. S. and Canadian agriculture. IATRC Working Paper Number 97-3. Presented at the International Agricultural Trade Research Consortium, Washington, DC, December 15-17, 1996.
- Vollgrath, T.L. 1998. RTA's and agricultural trade: A retrospective assessment. In *Regional Trade Agreements and U.S. Agriculture*, edited by M. E. Burfisher & E. A. Jones. Washington, DC: U. S. Department of Agriculture, Economic Research Service.
- Woodall, P., Wallach, L., Roach, J., & Patel, D. (2001). *Down on the Farm: NAFTA's Seven-Years War on Farmers and Ranchers in the U.S., Canada, and Mexico*. Washington, DC: Public Citizen's Global Trade Watch.
- World Trade Organization. 2000. *International Trade Statistics 2000*. Geneva, Switzerland: World Trade Organization.
- Worth, T. 1998. Regional trade agreements and foreign direct investment. In *Regional Trade Agreements and U.S. Agriculture*, Agricultural Economic Report Number 771, edited by M. E. Burfisher & E. A. Jones. Washington, DC: U. S. Department of Agriculture, Economic Research Service.

APPENDIX A

Concurrent GATT UR Impacts on Agriculture

All three NAFTA partners -- Mexico, Canada, and the U.S. – have participated in the GATT negotiations since 1986 when Mexico joined the GATT. The current implementation period of the Uruguay Round commitments for most OECD countries is 2000. Because of its developing country status in the WTO, Mexico has until 2004 to implement its UR commitments and to adjust tariff rate quotas, tariff rates, and export subsidies.

The OECD just released “The UR Agreement on Agriculture: An Evaluation of its Implementation in OECD countries.” This document indicates that the immediate quantitative effects of UR were limited and difficult to distinguish from other national policies (e.g., the Farm Bill in 1996) and from bilateral and other multilateral agreements. However, the overall impact of the UR was thought to be limited because of the weakness of its measures and the historically high level of support from which reductions were to be made. However, the UR was successful in converting non-tariff barriers to tariffs, though the net impact of this provision may be limited because tariffs are generally higher than in non-agricultural commodities.

The OECD analysis of Mexico was limited because Mexico had not notified the WTO of its tariff quotas for 1995 and 1996 and onward (the only country with Hungary not to have done so). In Canada, the average tariff on agricultural and food products has increased dramatically between 1993 and 1996 reflecting the tariffication of quantitative restriction (quotas to support its supply management program).

The PSE is the lump sum transfer that would be needed to maintain the agricultural sector income if all government support to that sector were removed, assuming constant world price and fixed output. The share of PSE is the fraction representing PSE over the producer’s value of production. In 1992, Canada’s total agricultural PSE amounted to US\$5.8 billion, Mexico’s PSEs amounted to US\$1.3 billion, and US PSEs amounted to US\$23.8 billion (USDA, 1996). Thus, although all three countries had a positive PSE and thus subsidized their agriculture, the share of PSE was highest in Canada, representing 36% of producers’ value of production, second in the U.S. at 19%, and least in Mexico at only 8%. Following the GATT, payments have been mainly decoupled. Now that world prices are low, some countries are finding it hard to meet their commitments. The U.S., for instance, pays less in loan payments (coupled) but increased its market assistance payments since 1998.

Canadian predictions of the impact of the GATT UR on the Canadian agricultural sector were not available for the writing of this report. In the 1995 Midterm Outlook, Agriculture Canada assumed that the Canadian transportation subsidies would be eliminated and other policies, such as farm revenue support, would respond to the GATT UR. Both Canadian and U.S. agriculture were expected to gain from the GATT multilateral trade agreement, because as net exporters, both countries were expected to benefit from increased market access and higher world prices. The GATT agreement was implemented over a 6-year period from 1995-2000.

The driver of changes for the OECD model is the increase in GDP caused by the GATT UR of 0.7% to 1.5% in the U.S., Mexico, of 1.1% to 2.5% and other developed countries above what would happen without the GATT UR.

ERS modeled and used analysts' judgment to predict the impact of NAFTA and the UR on U.S. agriculture. The UR baseline does include the effects of NAFTA. The effects are believed to be underestimated, because without the UR, countries would have gone to more protectionism, and the trend line used for the baseline would have been worse than the one used for the baseline (e.g. increase in economic growth and accompanying demand). The baseline represents the educated guesses of experts as to where the agriculture economy is heading in the next 6 years. Predicted impacts on the U.S. agriculture are larger post-2000 due to predicted growth in world demand following an increase in world income due to GATT. Based on their CGE model, the GATT Secretariat predicted world income gains of US\$109 to US\$510 billion by 2005 with the GATT. The World Bank/OECD predicted gains of \$US 213 billion in 2002.

Prices, revenues, and government payments

ERS (1994) predicted that the GATT would open new export markets to U.S. producers that would pay higher prices and thus increase farm revenues by as much as \$1.3 billion in 2000. Government outlays were predicted to decrease by the same amount by 2000, due to large reductions in deficiency payments and in export subsidies. Cash receipts were expected to rise to \$4 to \$5.4 billion. The U.S. was also predicted to gain from increased demand for agricultural products, resulting from expected increases in world income (which was expected to increase by as much as US\$5 trillion in the 10 years following the agreement). U.S. exports were predicted to increase to \$1.6 to \$4.7 billion by 2000 (up to 50%). Grains, with 41% expected growth, and animal products, with 35% expected growth, were expected to account for 75% of U.S. export growth. Cotton and horticultural product exports were expected to increase by 6% and soybean exports by 11%. Growth in these exports was expected to be greater than what would be expected without the UR.

Jobs

Job creation for high-value and value-added products was expected, with agricultural export-related employment creation estimated at 41,000 to 112,000 jobs by 2000 and 190,000 in 2005. The animal product sector was predicted to gain more than half of these jobs, with an expected increase of 23,500 to 54,200 jobs. The bulk of the remaining additional jobs were expected to be in the grains and feeds sector.

Crop Sectors

In the field crop sector, an initial dampening effect was expected, to be followed by an increase in exports starting in 2000. Wheat and feedgrain exports were expected to be similar to or slightly below baseline levels in the first 3 years, but then to increase by 7.5% above the baseline level. Cotton exports were expected to increase by 8%, soybean

by 3%, and rice by 13%. Prices for these commodities are expected to increase by 2-3% above baseline, with rice prices increasing by 11%. Planted acreage changes would be small. Most gains were expected to result from the EU's reduction in subsidized exports. Corn exports were expected to rise by 200-300 million bu (5-10% increase from the baseline), and gross farm receipts from corn were expected to rise by up to 5%. Canada was also expected to benefit from increased wheat exports. Soybean effects were expected to be small, given that tariffs and non-tariff barriers on this commodity were already low. Soybean exports were predicted to grow by 3% for 2005, and prices were predicted to be 9% higher.

Livestock sector

The impact on the dairy sector was expected to be minor for the U.S.. U.S. cattle production was expected to increase after 2000, and the pork and poultry sectors were expected to expand beginning in 1997. U.S. broilers were expected to increase. World trade in beef is expected to increase by up to 4% by 2000, and up to 11% by 2005. The value of beef exports was expected to increase by 11-19% in value (by 7-11% in quantity) by 2000. Beef imports were expected to increase in quantity by 11 to 15 %. World trade in pork and poultry was expected to increase by 1% to 5% above the baseline. U.S. imports were expected to decrease by 5-15% and exports to increase by 10-15% by 2000. U.S. exports of poultry are expected to increase by 9-25% above the baseline.

Specialty Crops

U.S. horticultural trade was expected to increase from the baseline, and imports of frozen asparagus, broccoli, and cauliflower were expected to increase more than exports. Exports of tomatoes were expected to increase more than imports. Fresh vegetable trade was mainly with Canada and U.S. already accounted for in NAFTA, but all exports of fruits and vegetables were expected to be above the baseline (which does include NAFTA).

APPENDIX B

The *Aglink* model is OECD's forward-looking commodity market policy modeling tool. This modeling effort began in 1992, was in operation by 1994, and is now used by many countries around the world. Calibrated with information from questionnaires completed by Member countries on an annual basis, the model is used for projections of medium-term commodity market developments, as well as for the simulation of particular policy scenarios. *Aglink* takes commodity interrelations into account, covers the most important agricultural and trade policies, and allows for the endogenous determination of national and world market prices. It is a dynamic model that was used recently to evaluate the effects of further agricultural trade liberalization (OECD, 1999). Canada, whose economist Pierre Charleboix help initiate the *Aglink* model, has used the model for its own predictions since 1995.

SWOPSIM is a partial equilibrium model used by ERS to model its regional trade agreements. It was used to model the U.S., Mexico, and rest of the world effect of the NAFTA with 29 agricultural commodities (9 livestock products, 9 grains and oilseeds, 6 horticultural

commodities, and 5 other crops) (Liapis, Krissof, and Neff, 1991). In this static, partial equilibrium model, world trade income growth is not endogenous (unlike the CGE models described above). While agricultural markets are more detailed, other markets are not explicitly modeled. In addition, economies of scale and technological changes are not modeled (Liapis et al. 1991). Trade barriers are modeled as price wedges.

The FAO/WFM model does not include a processing sector. Instead processed commodities are transformed in primary product equivalents. Commodities not in the model include coffee, cocoa, tea, sugar, banana, rubber, and bovine hides. 137 individual countries and 10 aggregates of small countries are included in the model. GDP growth estimates for each country are from the International Economics Department of the World Bank. FAO projections were based on elasticities supplemented from SWOPSIM and from the OECD MTM model. The WFM is a price equilibrium model that is interactive, allowing for the simultaneous clearing of supply, demand, trade, stock levels, and prices. The model is also dynamic, in the sense that outcomes in one year can be used to allow predictions of subsequent outcomes in future years.

Figure 1
US Exports To Canada

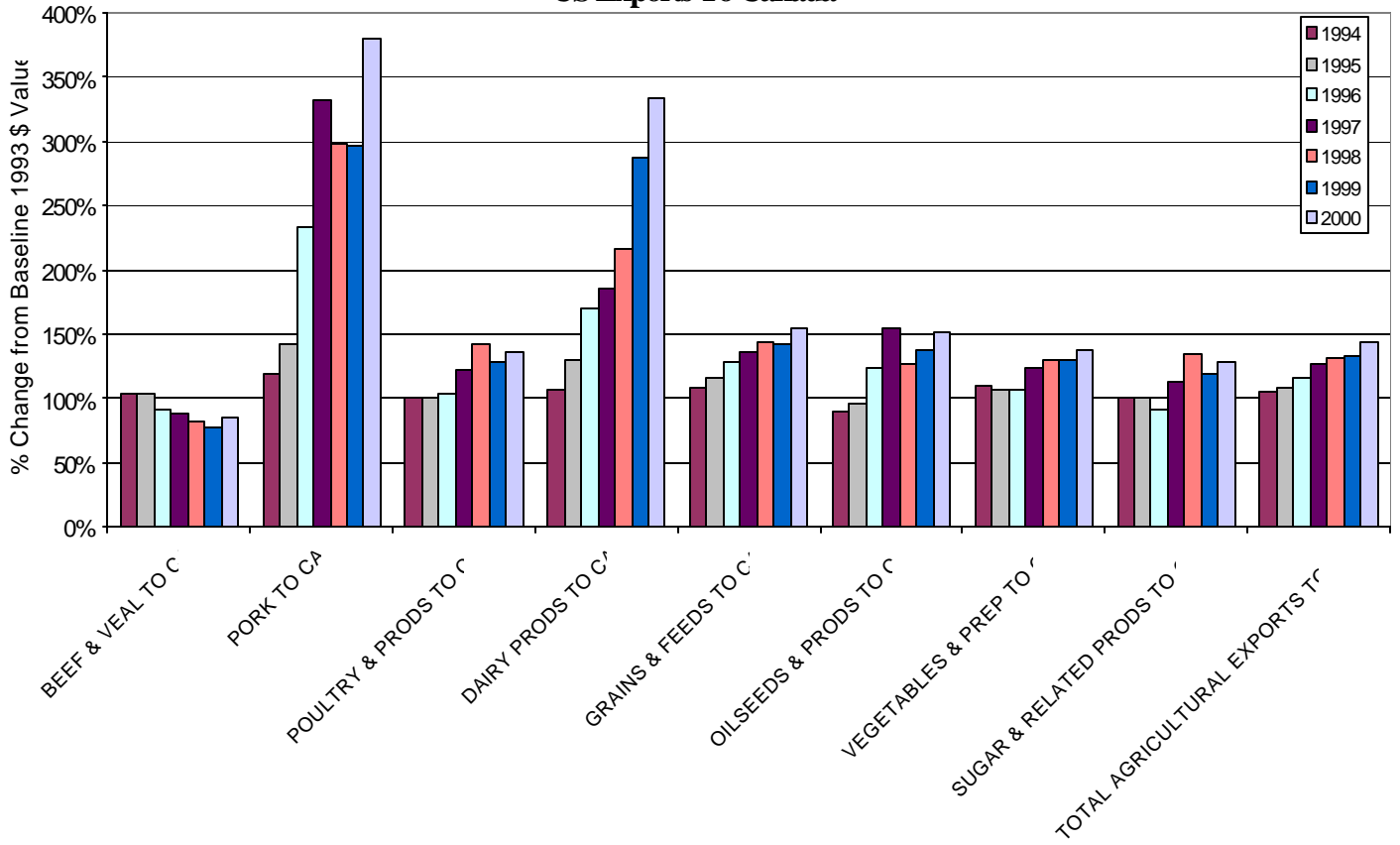


Figure 2
US Exports to Mexico

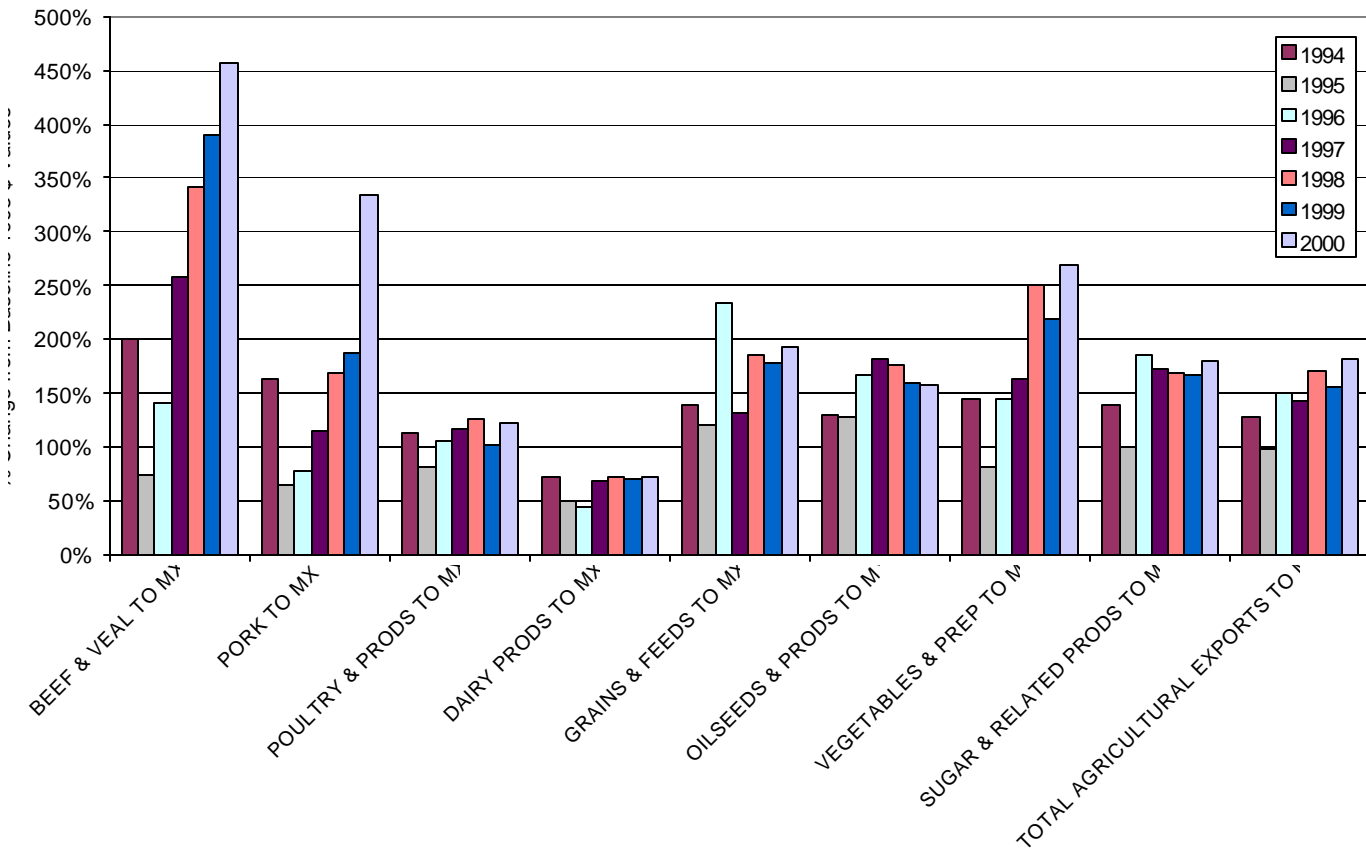


Figure 3
US Imports From Canada

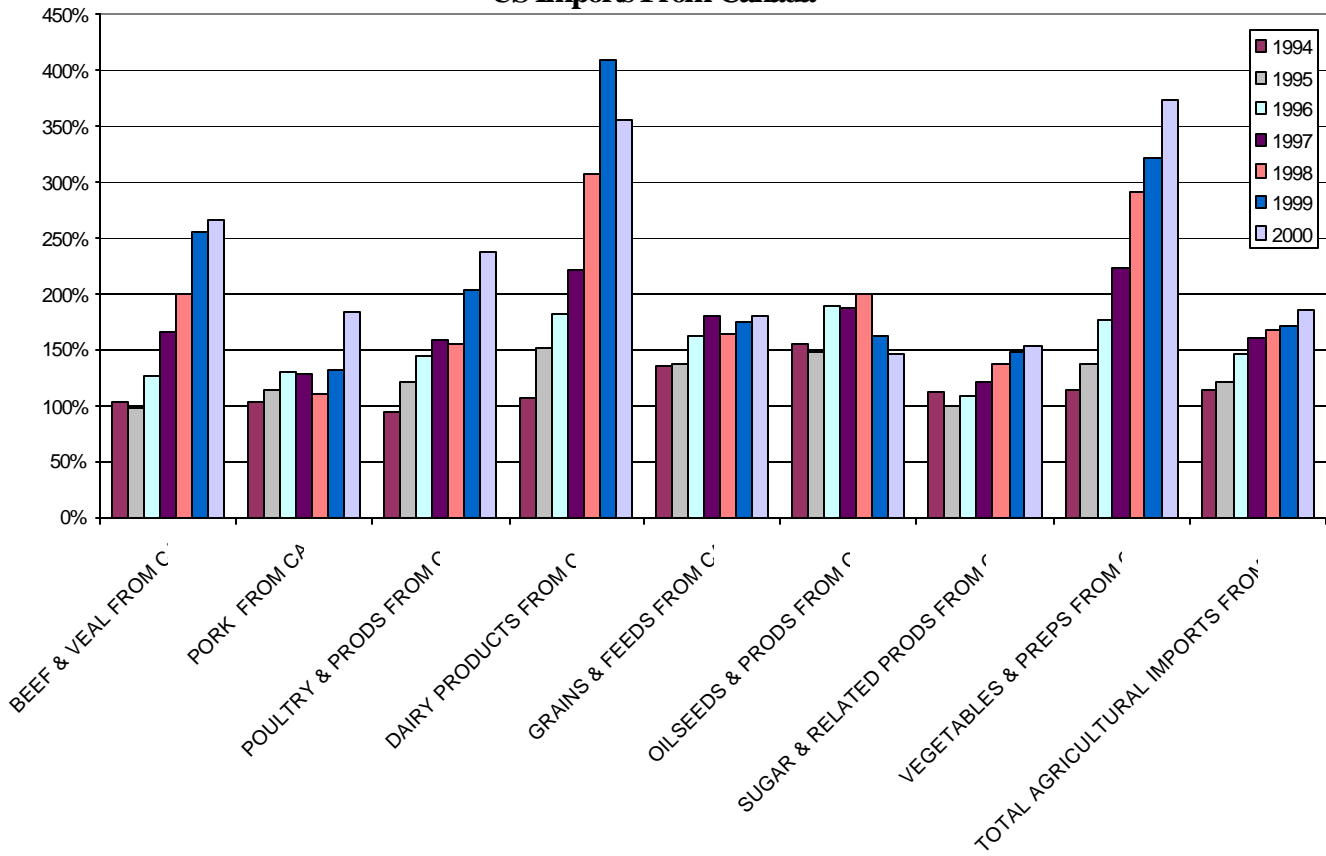


Figure 4
US Imports From Mexico

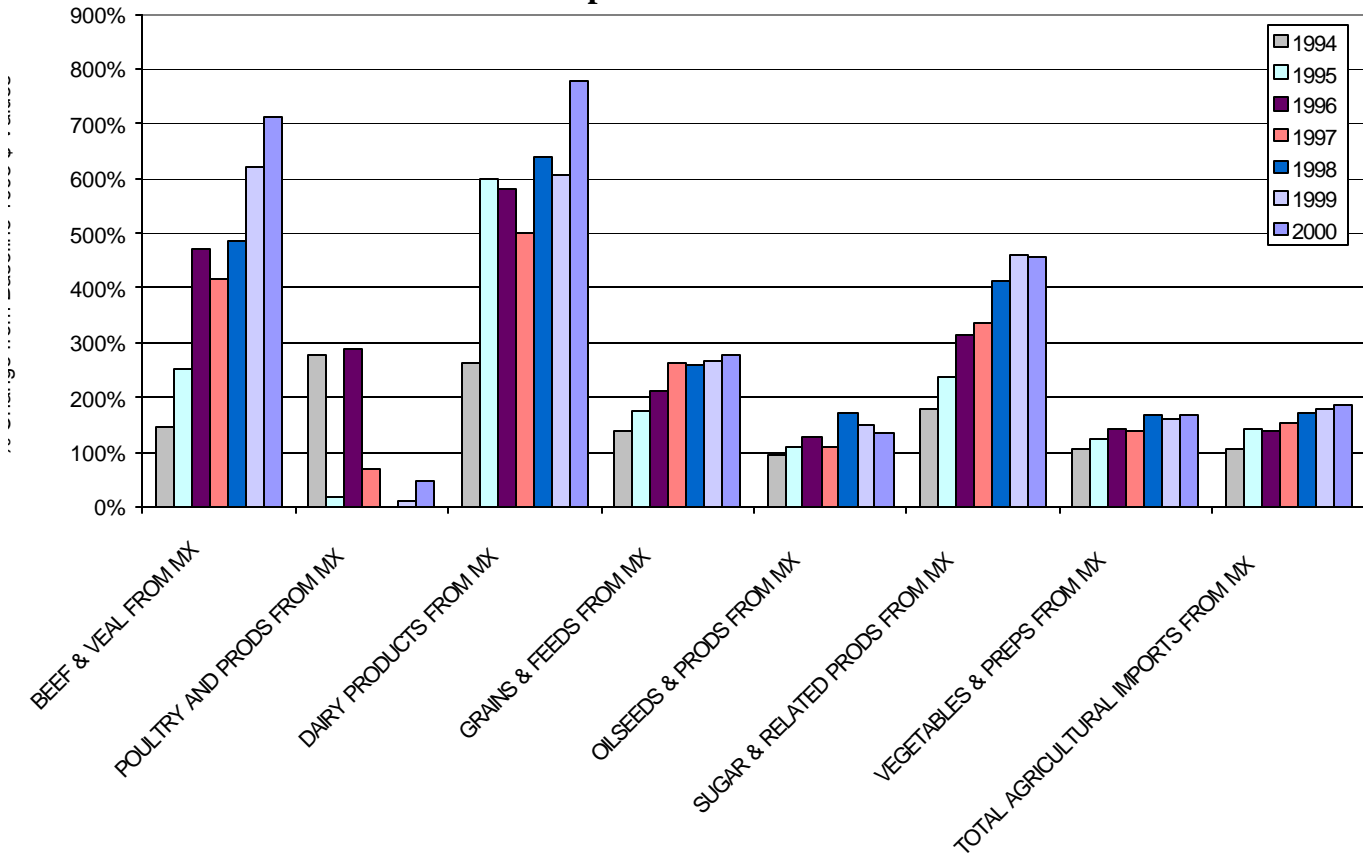


Figure 5
World Dairy Prices: 1993 – 2000

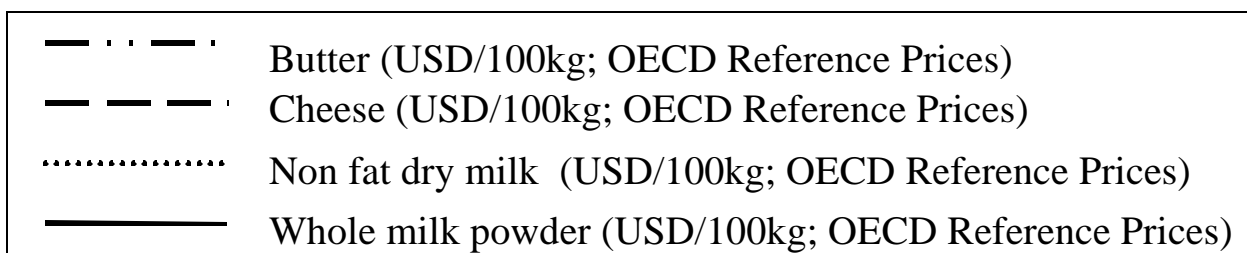
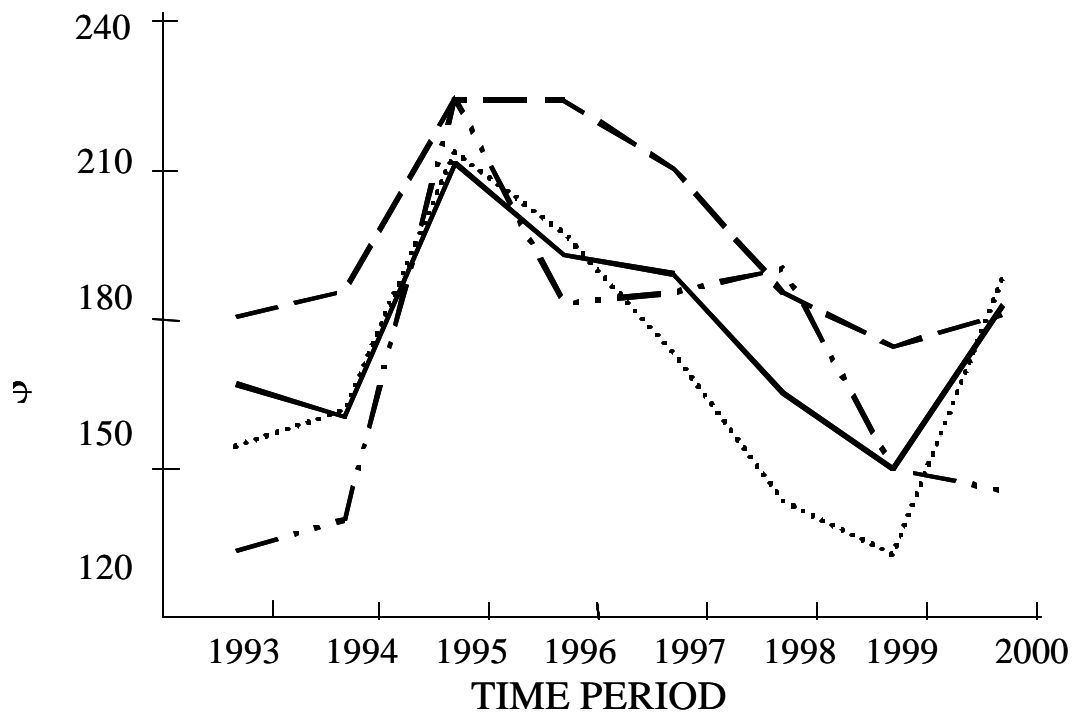


Figure 6
World Grain/Corn Prices: 1993 – 2000

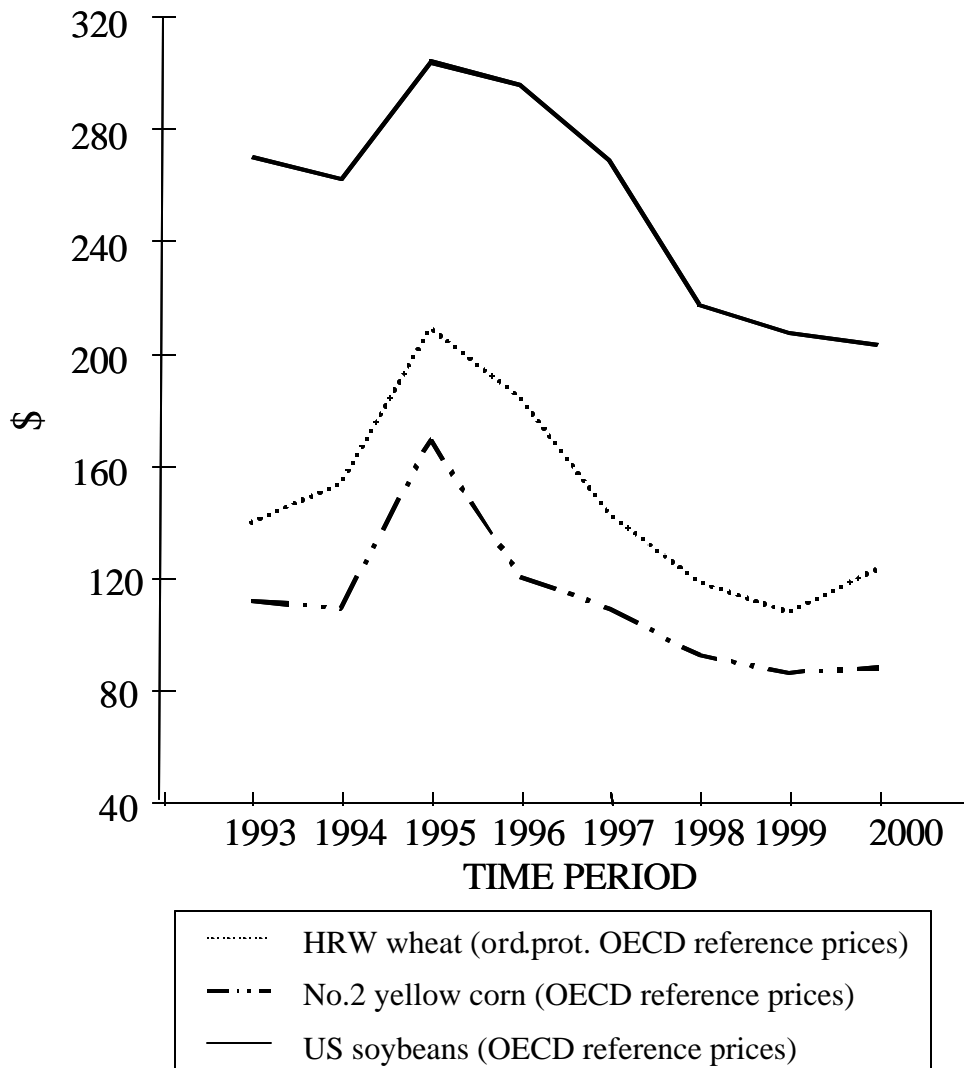


Figure 7
World Meat Prices: 1993 – 2000

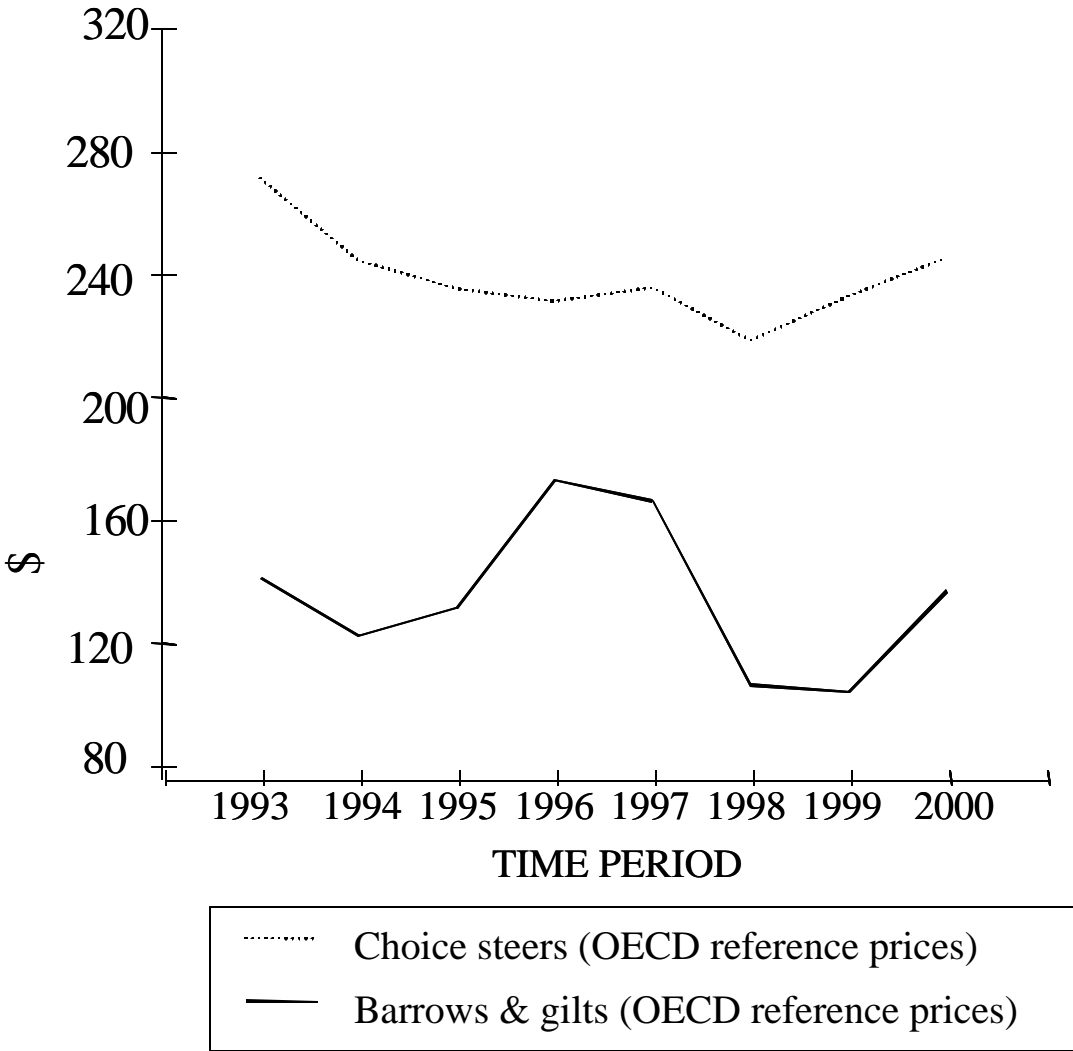
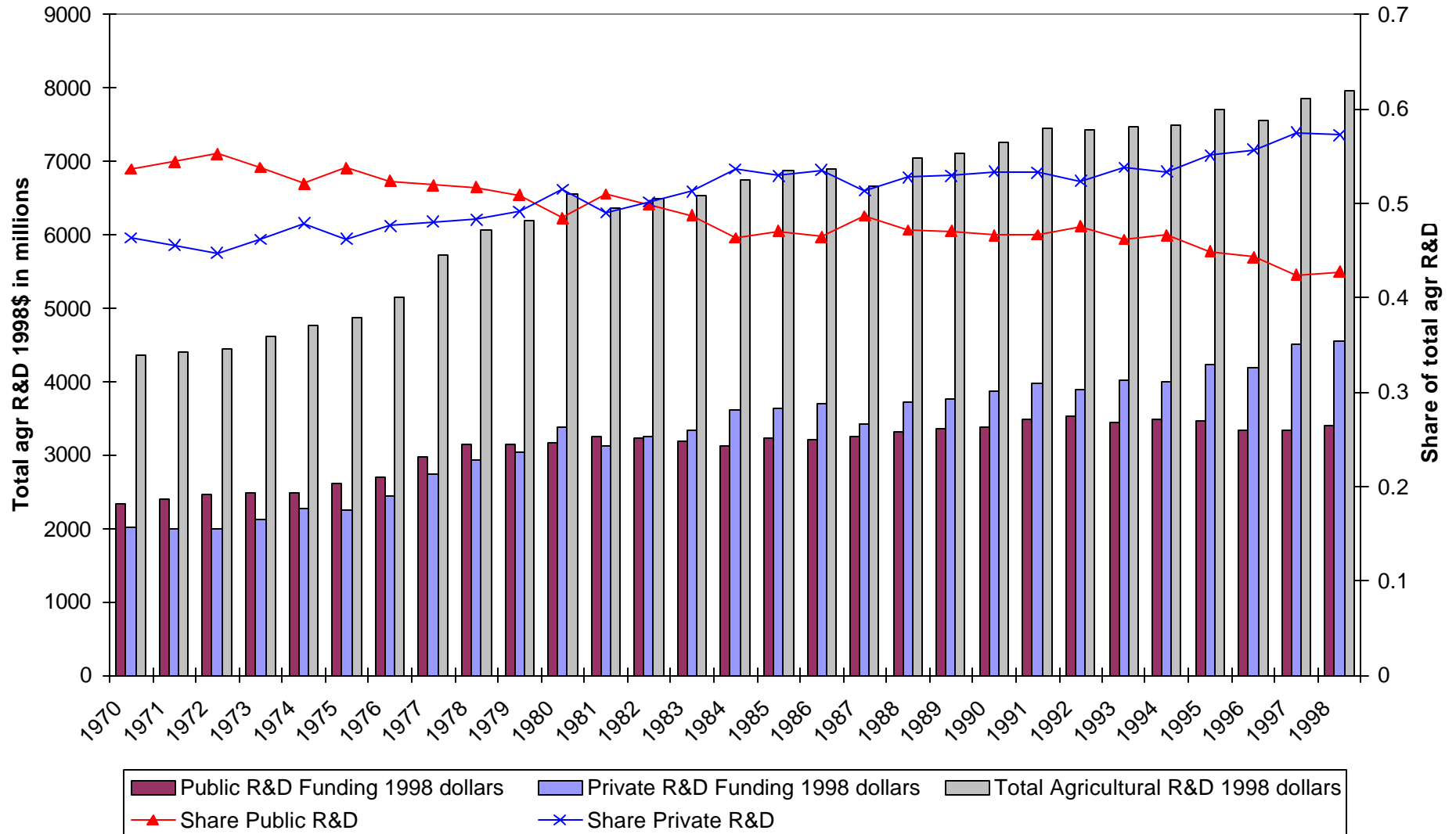


Figure 8
US Agriculture R&D Investments (1998 \$ in millions)



Source: Public numbers based on USDA Current Research Information System, *Inventory of Agricultural Research*, various years. Private numbers based on Klotz, Fuglie and Pray (1995).