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TRADE IN MINOR OILSEEDS: A SPATIAL EQUILIBRIUM ANALYSIS OF SUNFLOWER AND CANOLA

D. Demcey Johnson, Vidyashankara Satyanarayana,
Bruce L. Dahl, and Frank J. Dooley

Department of Agricultural Economics
North Dakota State University
Fargo, ND 58105

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Abstract

A spatial-equilibrium model of trade in sunflower and canola (seed, oil, and meal) is used to assess alternative trade policy scenarios and their implications for North American producers. Simulations address effects of the U.S. SOAP program, NAFTA, the GATT agreement, EU supply restrictions, and tariffs in major import markets.

Keywords: minor oilseeds, sunflower, canola, trade.

Highlights

Impacts of trade liberalization (NAFTA and GATT) and policy reforms in the United States and Canada have been extensively studied by agricultural economists. However, much of the published literature has focused on major commodities, such as wheat, corn, and soybeans. Scant attention has been given to minor oilseeds, such as sunflower or canola, despite their emerging importance to producers in the northern plains and Canada.

Sunflower and canola (rapeseed) are valued primarily for their oils. Although world trade in vegetable oil is dominated by soybean oil, consumption of sunflower and canola oil have each grown rapidly, aided by global shifts toward premium cooking oils. The United States is a major exporter of sunflower oil, along with Argentina and the European Union (EU). Until recently, U.S. exports were subsidized under the Sunflower Oil Assistance Program (SOAP). Canada is a major exporter of both canola oil and seed, and acreage has expanded sharply in recent years.

Sunflower and canola oil are considered close, but imperfect substitutes. Their shares of consumption vary widely across world regions due to locational factors (distance from production) and tariff barriers, in addition to market-specific preferences. Prospective changes in trade flows as a result of the Uruguay round and other policy developments in Europe, South America and China could have important consequences for North American producers of both minor oilseeds.

This paper presents simulation results from a spatial-equilibrium model. Based on quadratic programming, the model includes all of the world's major producing and consuming regions for sunflower and canola. The simulations focus on trade policies (i.e., tariff reductions and elimination of export subsidies) and on structural changes in the oilseed sectors of selected regions (i.e., EU acreage reductions, improved oil yields in China). Following are some of the principal results:

- The SOAP program had a significant impact on U.S. sunflower oil export volume, domestic crushing, and producer prices. Model simulations (using FY 1994 subsidy levels) indicate that U.S. sunflower oil exports are 60 percent higher with SOAP. Domestic crushing of sunflower is 42 percent higher with SOAP, and producer prices (sunflower seed) are 18% higher. The termination of this program under new farm legislation will represent a challenge to the U.S. sunflower sector.

- Elimination of Mexico's import tariffs will have little impact on the U.S. sunflower or Canadian canola sectors. However, the extension of NAFTA to other countries could lead to major benefits. If Argentina and Chile accede to the free trade area and Argentina eliminates its existing export subsidies for sunflower oil, U.S. and Canadian producer revenue would increase by 3-4 percent. There would be small further gains if the free trade area were extended to other Western Hemisphere countries.

- The GATT agreement will have minimal impact on North American producers because substantial barriers to trade will remain after its full implementation. For comparison, a global free-trade scenario was analyzed. This shows increases in oil export volume from the United States (sunflower) and Canada (canola), and sharply higher prices and producer revenue.

- China is emerging as a major force in the world market. While elimination of Chinese tariffs on oil and meal would benefit North American producers of minor oilseeds, production shifts in China (toward high oil-yielding varieties) could have the opposite effect.

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1. INTRODUCTION

Sunflower and canola (rapeseed) are produced and traded throughout much of the world. Because they represent small parts of the U.S. oilseed sector (dominated by soybeans), they are referred to as "minor oilseeds." Nevertheless, both crops have an important (or growing) regional presence in the U.S. northern plains and Canadian prairie provinces.

U.S. sunflower production and crushing are concentrated in North Dakota and adjacent states. Acreage has fluctuated widely during the past two decades due to changing market conditions and farm programs, but sunflower remains one of the few viable alternatives to wheat and barley in the northern plains.[1] U.S. canola acreage is relatively small, but has been increasing (notably in North Dakota). Canada is one of the world's major producers and exporters of canola, and has expanded acreage in recent years. The significance of canola in Canada may be gauged by the fact that, in 1994, the farm-gate value of canola production was nearly three-fifths that of wheat (Canada Grains Council, 1995).

Both sunflower and canola are valued primarily for their oils, which are close, but imperfect, substitutes. Although world trade in vegetable oil is dominated by soybean oil, consumption of sunflower and canola oil has grown rapidly, aided by global shifts toward premium cooking oils. The United States is a major exporter of sunflower oil, along with Argentina and the European Union (EU). Until recently, U.S. exports have been subsidized under the Sunflower Oil Assistance Program (SOAP). Much of Canada's canola oil production is exported to the United States. Canada also exports canola oil to offshore markets, competing primarily with the EU.

Several recent changes in the trade policy environment hold major implications for North American producers. With full implementation of the North American Free Trade Agreement (NAFTA), Mexico will eliminate its tariffs on vegetable oil imports. NAFTA may eventually be

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*Johnson and Dooley are assistant professors, Satyanarayana is a research assistant, and Dahl is a research associate, Department of Agricultural Economics, North Dakota State University, Fargo.

[1]Among North Dakota crops, sunflower ranks fourth (behind spring wheat, durum wheat, and barley) in terms of cash value, ahead of hay, potatoes, sugarbeets, and dry edible beans (North Dakota Agricultural Statistics Service, *North Dakota Agricultural Statistics 1995*, pp 35-38). For background and economic analysis of the U.S. sunflower industry, see Bangsund and Leistritz.

extended to other countries, including South American producers, such as Argentina, with uncertain consequences for regional trade patterns. The Uruguay Round of the General Agreement on Tariffs and Trade (GATT) will also lead to tariff reductions around the world, although substantial trade barriers are likely to remain. Individual importing countries, such as Japan, maintain high rates of effective protection for domestic crushing. China, a major oilseed producer and consumer, is not a GATT signatory, but is under pressure to reduce its own import barriers. Ongoing changes in agricultural policies, notably in the European Union, will affect world supply conditions for minor oilseeds.

This study places North America's sunflower and canola industries in a global context. The objective is to analyze the impacts of trade liberalization and other policy changes on production, consumption, farm prices, and trade. The analysis is based on a static, spatial-equilibrium model of trade in sunflower and canola, including oilseeds and products (oil and meal). The model incorporates all of the world's major producing and consuming regions, with detailed treatment of North America. Through model simulations, we examine the impact of global policy changes on North American production, crushing, and exports.

The report is organized as follows. Section 2 provides background on the global market for minor oilseeds, trends in supply and demand by region, and policies of major exporters and importers. The spatial-equilibrium model is described in Section 3. Simulation results are presented in Section 4. Among other issues, the model simulations address the effects of NAFTA and GATT, trade barriers in Japan and China, EU supply restrictions, and U.S. and Argentine export subsidies (i.e., on sunflower oil). The report concludes with a summary and discussion.

2. BACKGROUND ON WORLD PRODUCTION AND TRADE

The supply and demand data reported in this section are from USDA's *PS&D View* database. Preliminary values for 1995 are based on information updated in March 1996.

All Oilseeds

Between 1980 and 1995, world production of all oilseeds increased from 150 million metric tons (MMT) to 254 MMT (Figure 2.1), largely due to increases in production area. Area planted to all oilseeds increased from 127.8 million hectares in 1980 to 181.0 million hectares in 1995 (Figure 2.2). Improved yields also contributed to higher oilseed production. Average yields increased from 1.2 MT per hectare (MT/ha) in 1980 to 1.4 MT/ha in 1995. The proportion of oilseeds crushed has been fairly stable throughout the 1980s and early 1990s, ranging from 78 to 84 percent of annual oilseed production. During this period, the total amount of oilseeds crushed increased from 127 MMT to 213 MMT. However, total oilseed exports increased only marginally, from 31 MMT to 43 MMT.

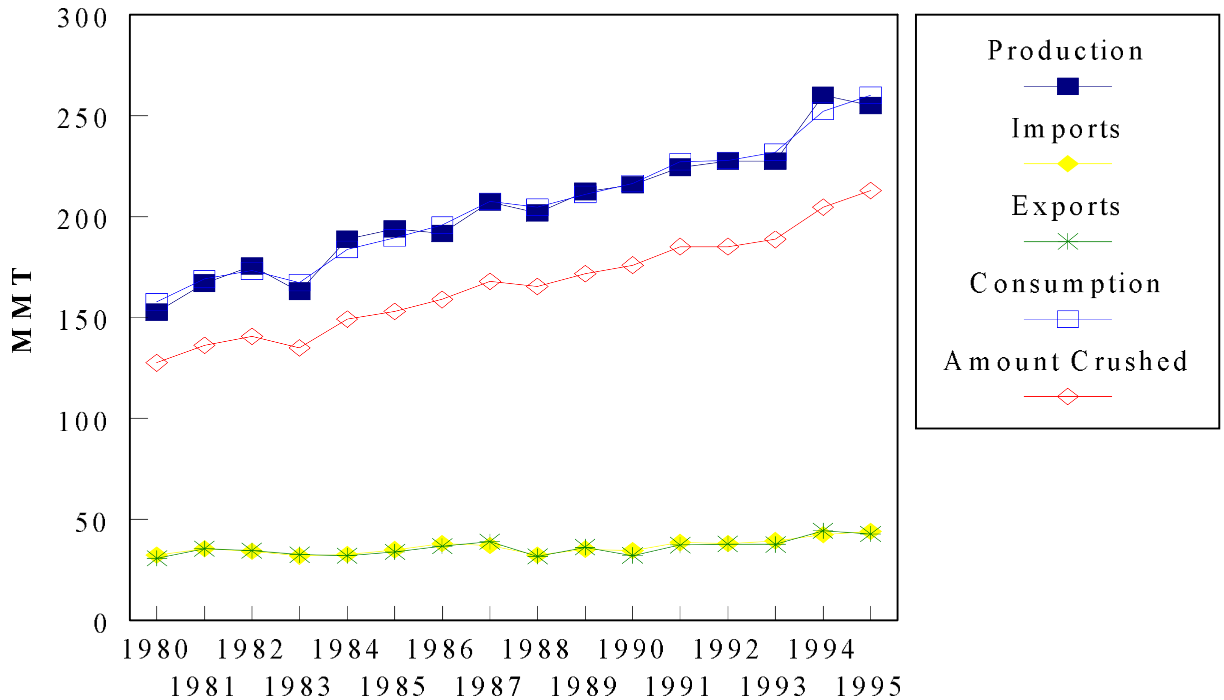

Figure 2.1. World Oilseed Production, Imports, Exports, Consumption, and Crush, 1980-1995

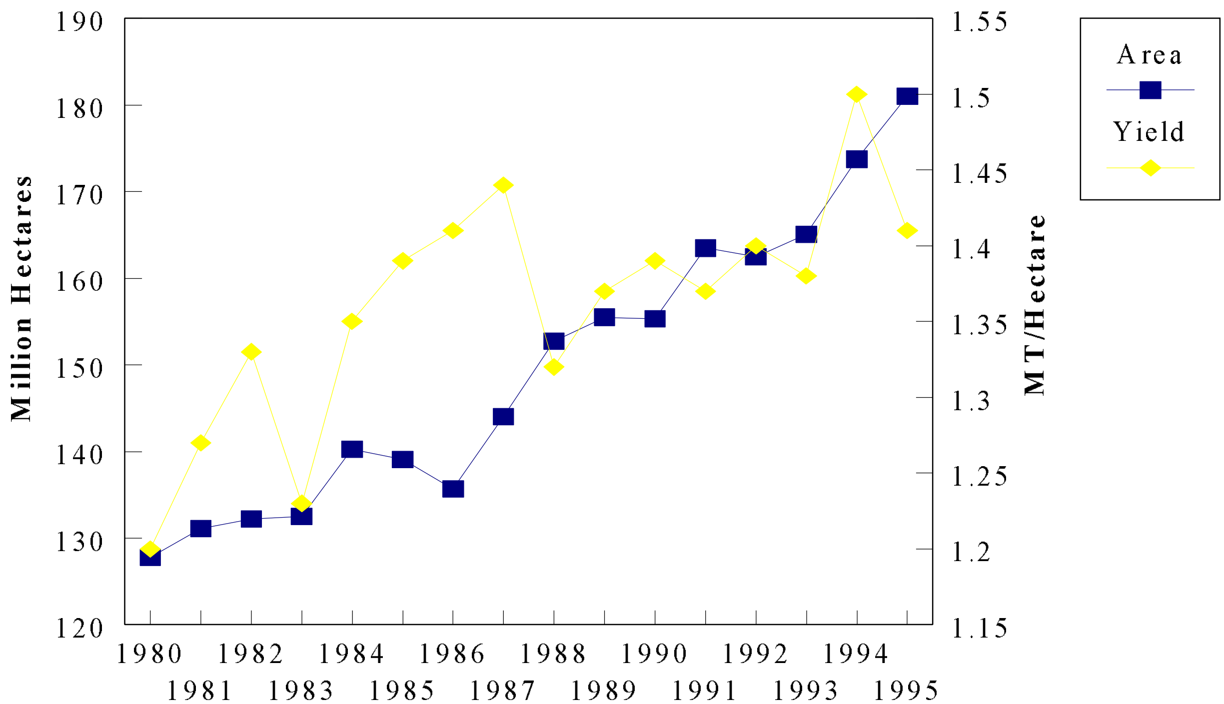

Figure 2.2. World Oilseed Production Area and Yields, 1980-1995

Production of vegetable oils increased throughout the 1980s and early 1990s. Oil production increased from 38.7 MMT in 1980 to 70.7 MMT in 1995 (Figure 2.3). Most oil production is consumed domestically. Trade in oils in the 1980s and early 1990s has ranged from 32 to 40 percent of total oil production. Exports of oils increased from 12.3 MMT in 1980 to 26.7 MMT in 1995.

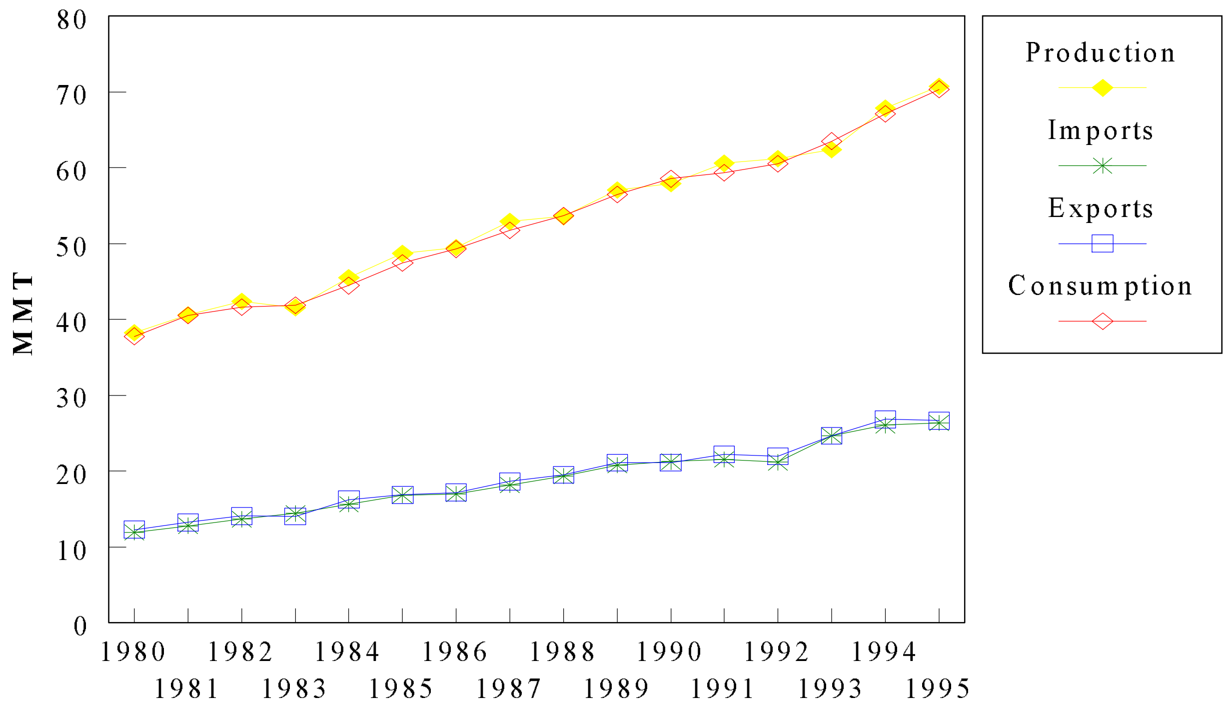

Figure 2.3. World Oilseed Oil Production, Imports, Exports, and Consumption, 1980-1995

Minor Oilseeds

The minor oilseeds market is dominated by rapeseed (canola)[2] and sunflowers. The combined production of rapeseed and sunflowers increased from 24.3 MMT in 1980 to 60.7 MMT in 1995. Production of rapeseed and sunflowers comprised 13.8 percent and 10.2 percent of total oilseed production in 1995, respectively.[3]

Rapeseed

Between 1980 and 1995, world production of rapeseed increased from 11.1 MMT to 35.2 MMT, a compound annual growth rate of 7.7 percent (Figure 2.4). Rapeseed's share of world oilseed production increased from 7.4 percent to 13.8 percent. World rapeseed crush increased from 10.5 MMT in 1980 to 30.8 MMT in 1995. Exports of rapeseed more than doubled from 2.3 MMT in 1980 to 6.0 MMT in 1995. Increased rapeseed production was due to increases in area and yields. Rapeseed production area more than doubled from 11.4 million hectares in 1980 to 24.7 million hectares in 1995 (Figure 2.5). World yields increased from 0.97 MT/Ha in 1980 to 1.42 MT/Ha in 1995.

Producers. China is the largest producer of rapeseed, producing 9.8 MMT in 1995. China and India have led the world in area planted to rapeseed (7.4 million and 6.5 million hectares, respectively). Canada ranks third in terms of acreage and the EU fourth (Figure 2.6). However, the EU enjoys a considerable yield advantage relative to other producing regions (Figure 2.7). EU production has appeared to stabilize, while Canada's has increased sharply due to acreage shifts (Figure 2.8). Canada and the EU each account for about 20 percent of world production. Lesser amounts of rapeseed are produced in Hungary, Poland, the Czech Republic, Bangladesh, Pakistan, the Former Soviet Union, and the United States.

Exporters. Rapeseed exports have been dominated by Canada and the EU (Figure 2.9). In the late 1980s and early 1990s, Poland also became a larger exporter, exporting a high of 729 thousand MT (TMT) in 1989. Canada and the EU accounted for 82 percent of world rapeseed exports in 1995, exporting 3.0 MMT and 1.9 MMT, respectively. However, most EU exports are to other EU countries.

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[2]The term, canola, refers to specific rapeseed cultivars originally developed in Canada. Canola has two advantages over traditional rapeseed varieties: 1) low levels of erucic acid (which makes the oil healthier in human diets) and 2) low levels of glucosinolates (which improve the value of meal in animal diets). The advantages of "double-low" varieties have led to their adoption in other world regions. However, the term canola is less widely used outside North America.

[3]For background on technical attributes of different oilseeds and processing technology, see chapter D-11 "Oilseeds--Processing" in *Grains & Oilseeds: Handling, Marketing, Processing*, Vol. 2, published by Canadian International Grains Institute, Winnipeg.

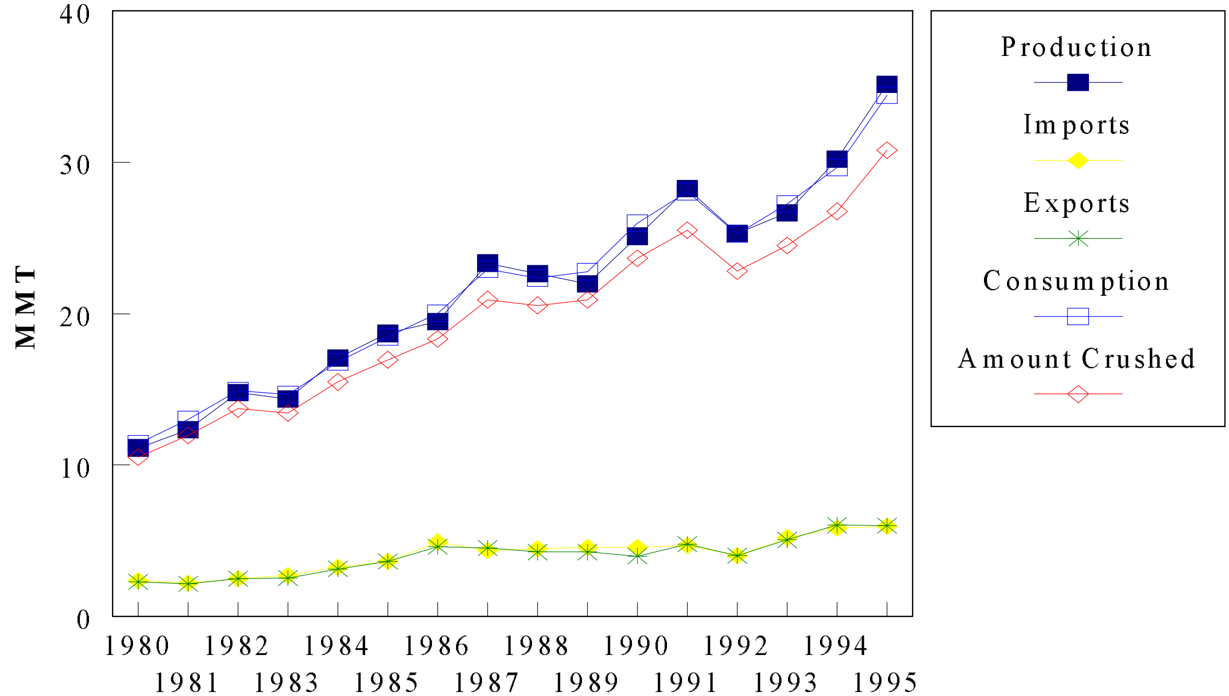

Figure 2.4. World Rapeseed Production, Imports, Exports, Consumption, and Crush, 1980-1995

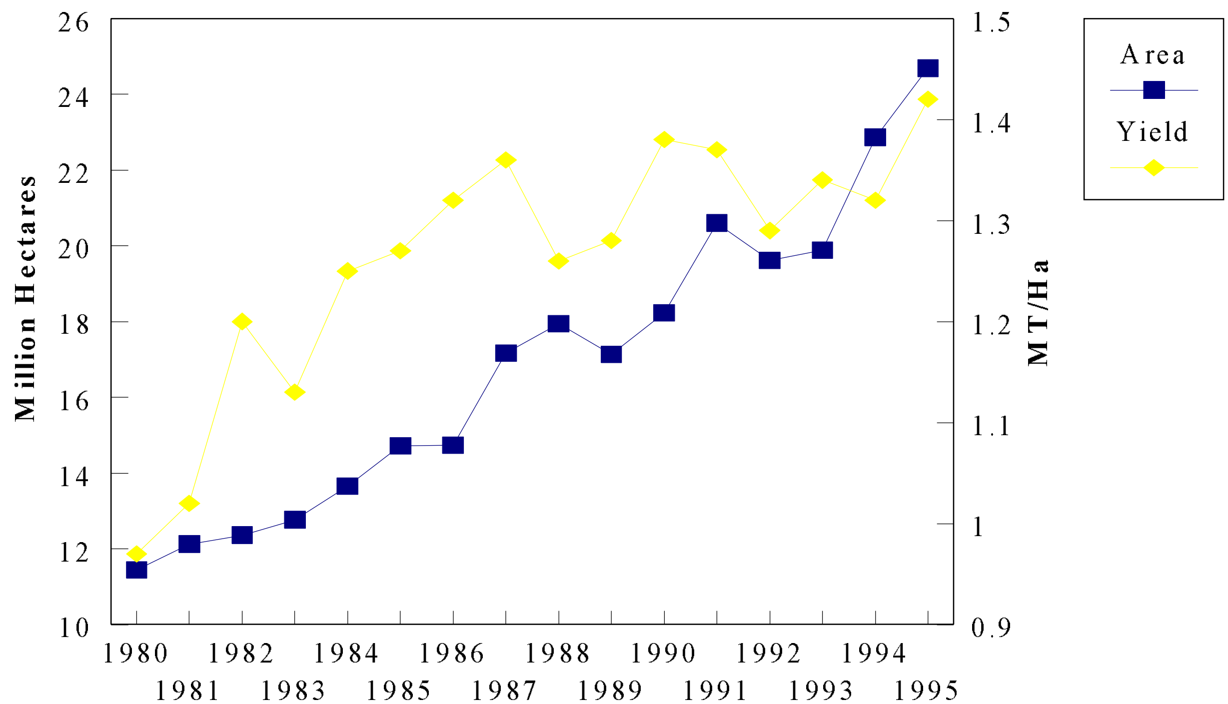

Figure 2.5. World Rapeseed Production Area and Yield, 1980-1995

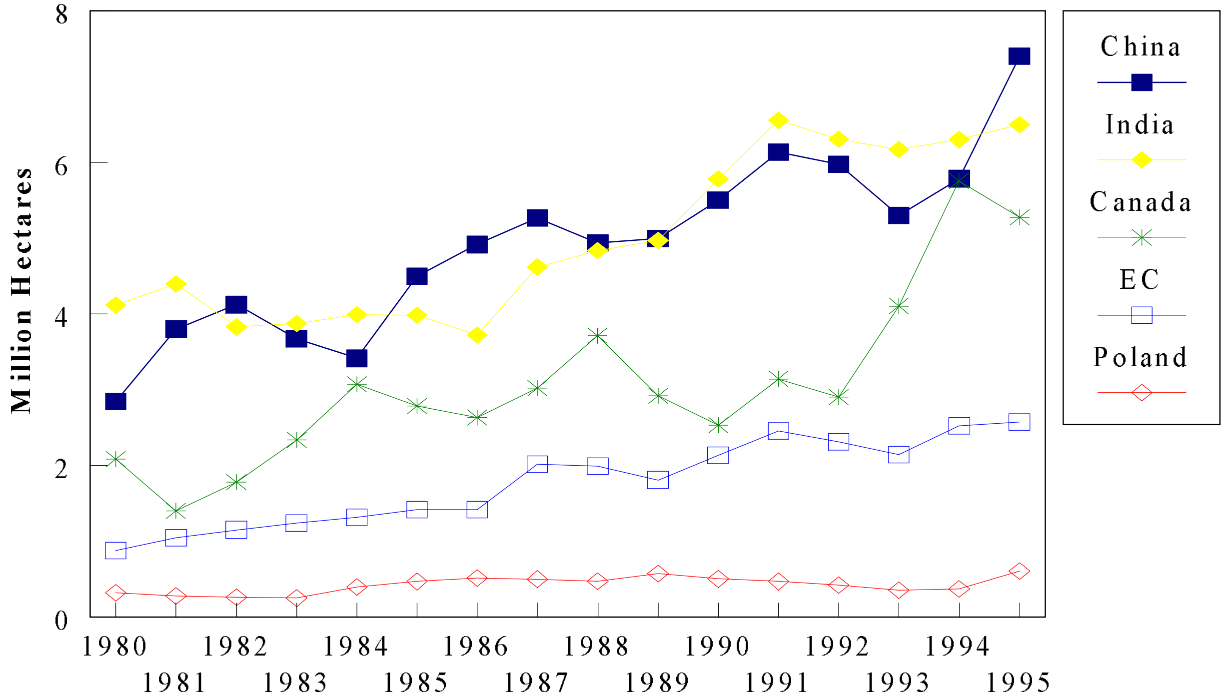

Figure 2.6. Rapeseed Production Area, by Country, 1980-1995

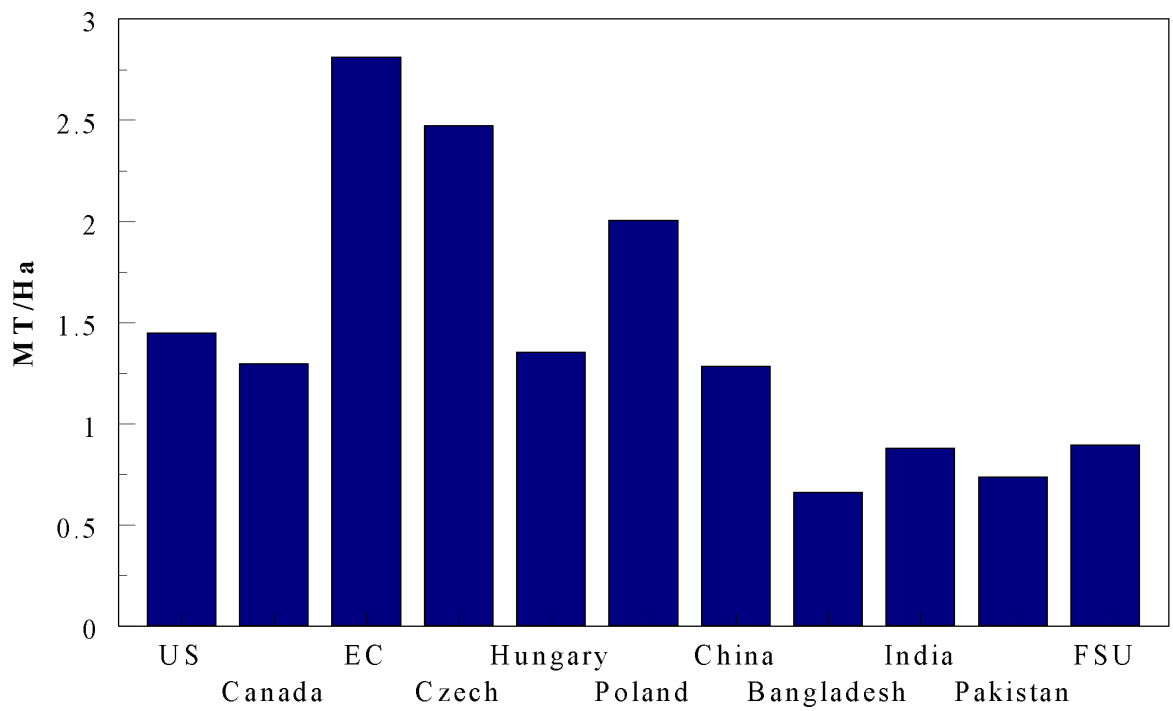

Figure 2.7. Average Rapeseed Yields, by Country, 1991-1995

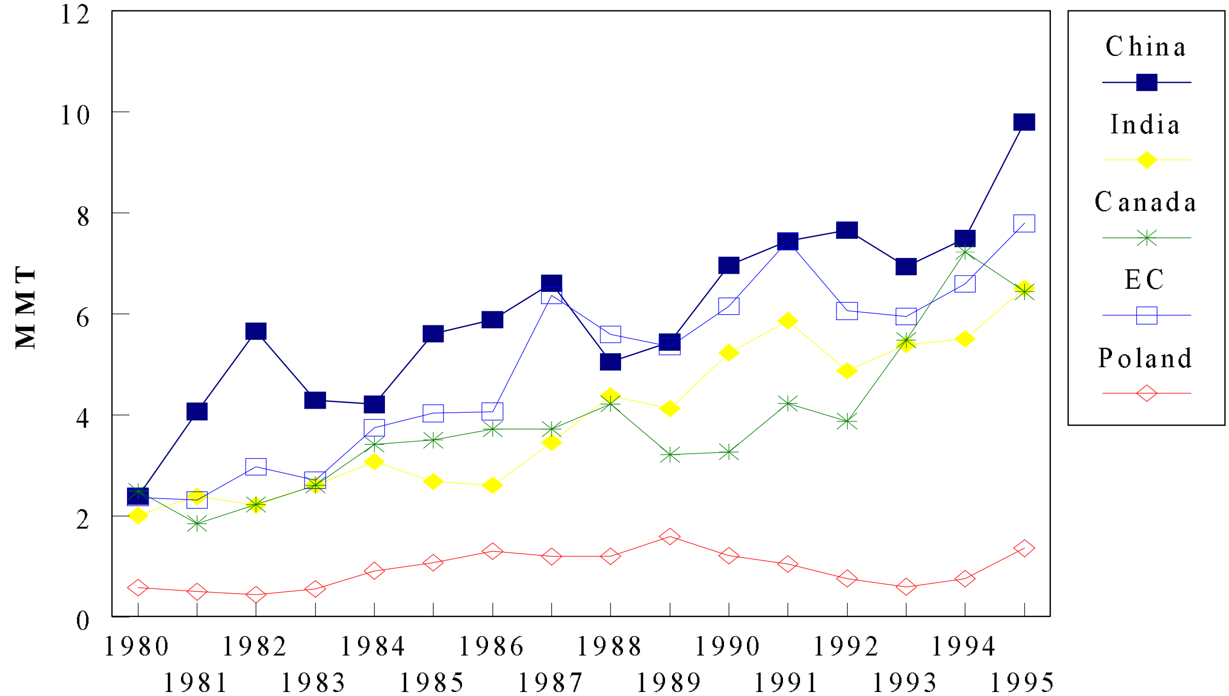

Figure 2.8. Rapeseed Production, by Country, 1980-1995

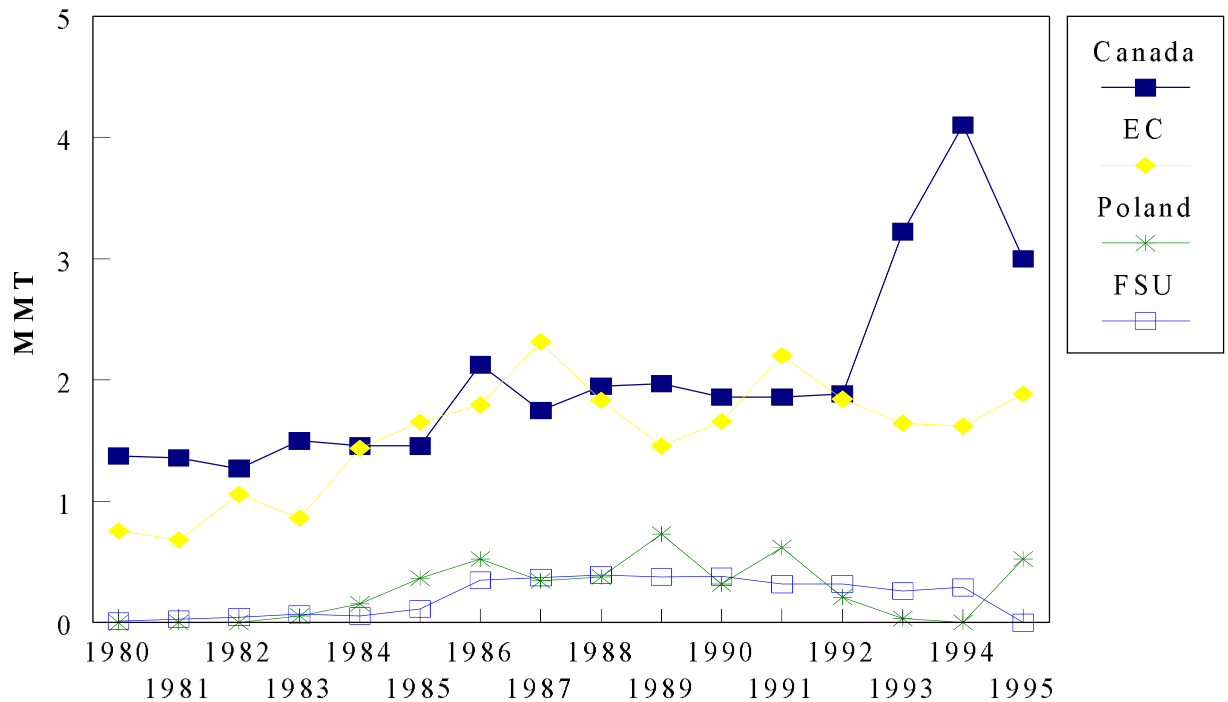

Figure 2.9. Rapeseed Exports, by Country, 1980-1995

Importers. The largest importers of rapeseed are the EU and Japan (Figure 2.10). EU imports tripled between 1980 and 1995, rising from 1.0 to 3.0 MMT. Japan nearly doubled its imports from 1.2 MMT in 1980 to 1.9 MMT in 1995. Together, both countries accounted for 82 percent of world rapeseed imports in 1995. The EU also exports rapeseed, but has been a net importer of rapeseed for most of the past decade. Minor importers of rapeseed in the early 1990s included the United States and Mexico, importing 0.19 MMT and 0.55 MMT in 1995, respectively.

Rapeseed Oil

Most rapeseed is crushed for oil. From 1980 to 1995, crushing accounted for 88-96 percent of world rapeseed production. Rapeseed oil production nearly tripled in that period, from 3.9 MMT in 1980 to 11.3 MMT in 1995 (Figure 2.11). Most rapeseed oil is consumed in the countries where it is produced. World exports of rapeseed oil increased from 0.8 MMT in 1980 to 2.5 MMT in 1995.

Producers. The three largest producers of rapeseed oil are the EU, China, and India (Figure 2.12). These three countries produced 70 percent of world rapeseed oil in 1995, with the EU producing 2.93 MMT, China 2.97 MMT, and India 1.93 MMT. Canada and Japan are the fourth and fifth largest producers, with 17 percent of world rapeseed oil production in 1995 (1.02 MMT and 0.81 MMT, respectively).

Exporters. The EU and Canada account for 87 percent of world rapeseed oil exports (Figure 2.13). Between 1980 and 1995, rapeseed oil exports from the EU increased from 0.54 MMT to 1.61 MMT. Canada increased its exports from 0.20 MMT to 0.55 MMT.

Importers. Many countries import rapeseed oil (Figure 2.14). The largest importer of rapeseed oil is the EU; however, the EU remains a large net exporter. Imports by other countries have changed markedly in the past decade. For example, India was a large importer of rapeseed oil in the 1980s, importing 0.34 MMT in 1987. India's imports of rapeseed oil dropped to 0.01 MMT in 1995. China was a small importer of rapeseed oil until 1987, when imports jumped to 0.48 MMT. China's imports fell off for a few years but have increased again to 0.65 MMT in 1995, making it the second largest importer of rapeseed oil. The United States has become the third largest importer of rapeseed oil, increasing its imports from 0.01 MMT in 1980 to 0.43 MMT in 1995.

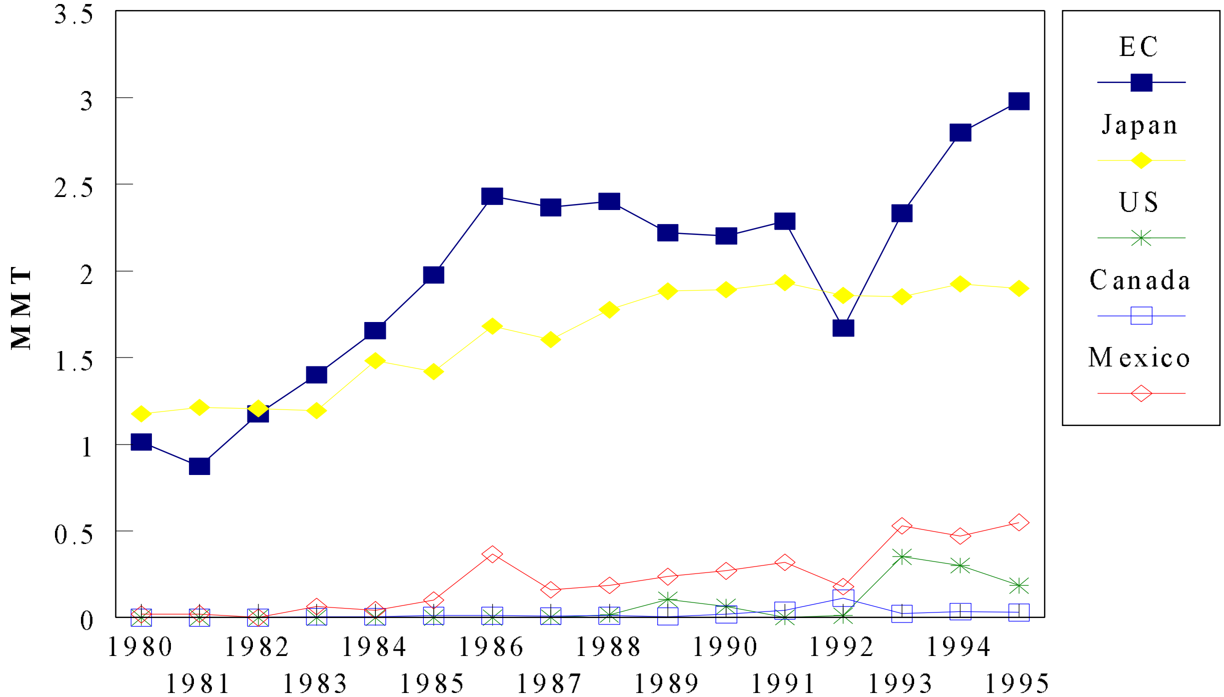

Figure 2.10. Rapeseed Imports, by Country, 1980-1995

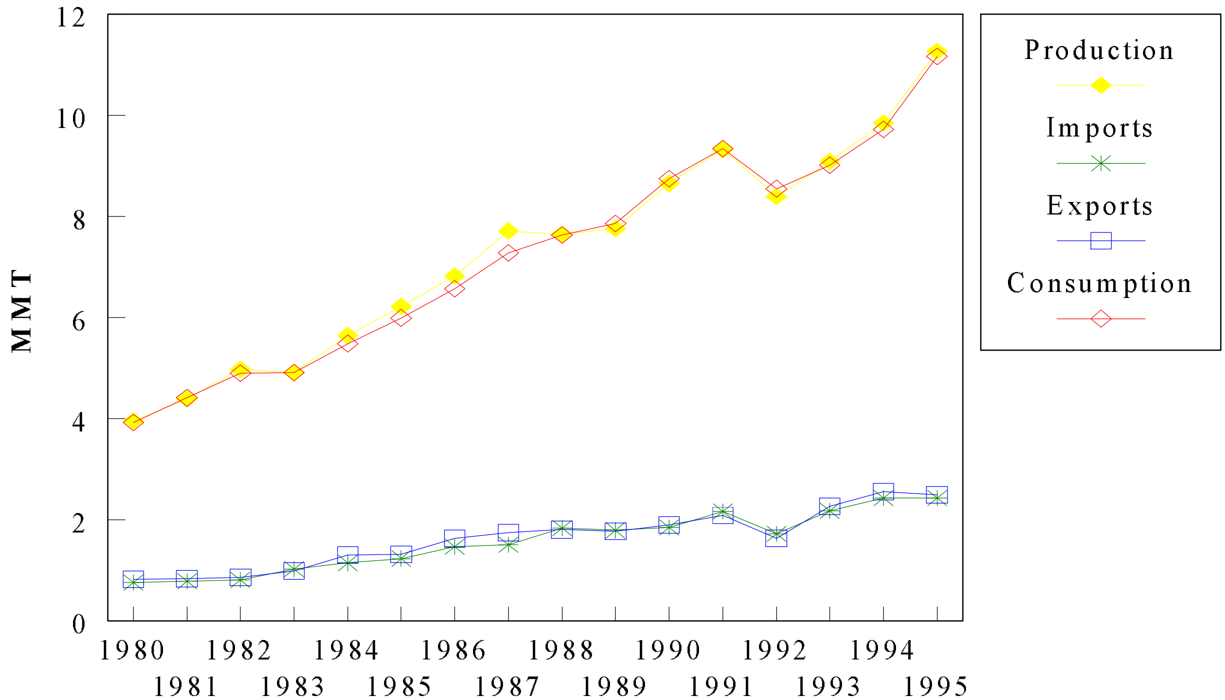

Figure 2.11. World Rapeseed Oil Production, Imports, Exports, and Consumption, 1980-1995

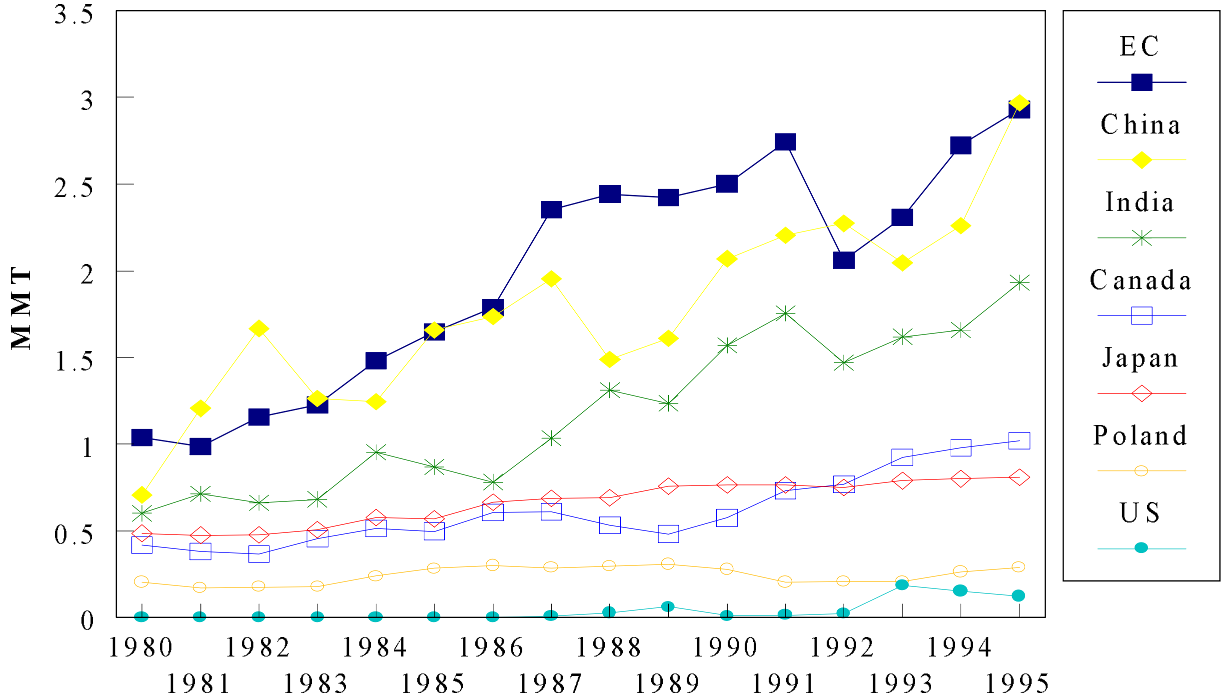

Figure 2.12. Rapeseed Oil Production, by Country, 1980-1995

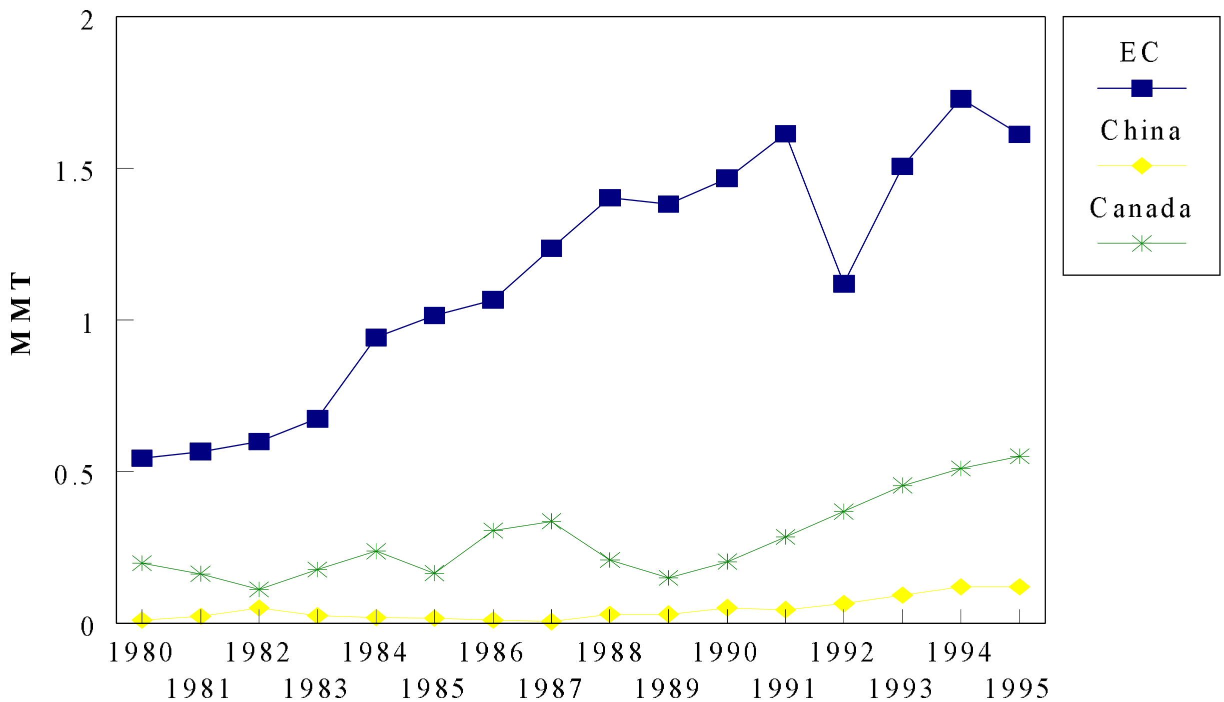

Figure 2.13. Rapeseed Oil Exports, by Country, 1980-1995

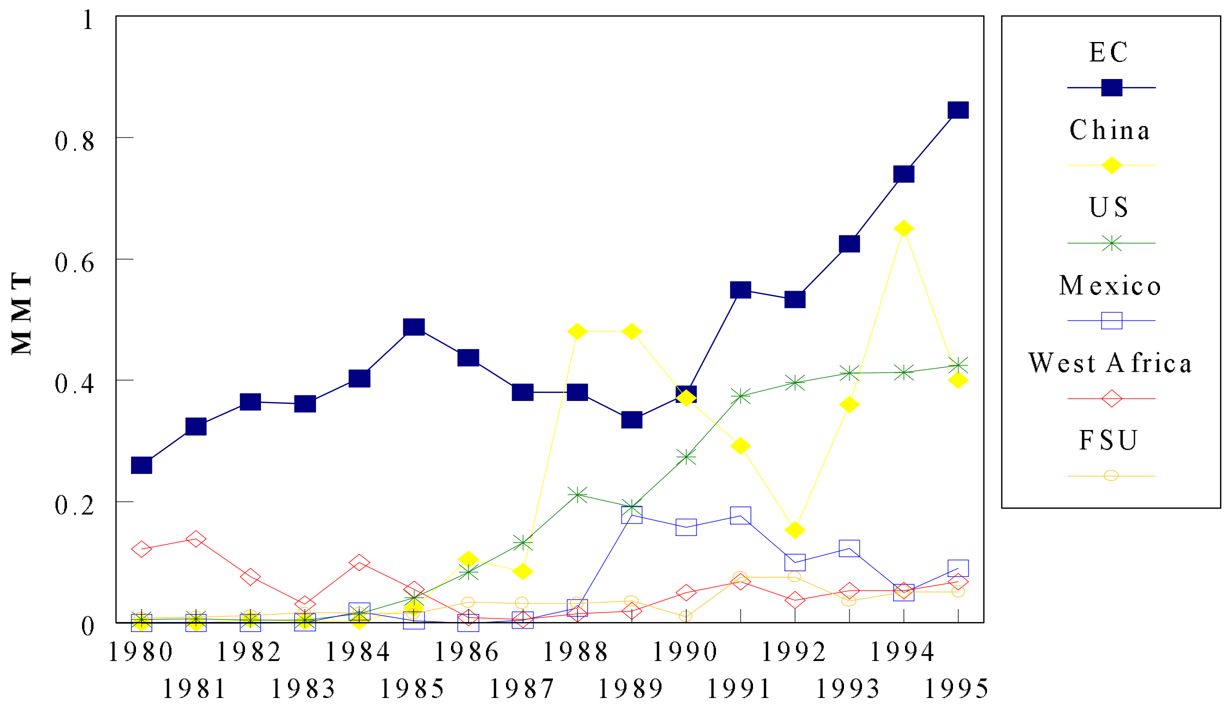

Figure 2.14. Rapeseed Oil Imports, by Country, 1980-1995

Sunflower Seed

World production of sunflowers increased from 13.2 MMT in 1980 to 25.9 MMT in 1995, an average growth rate of 4.5 percent per year (Figure 2.15). This was largely due to increased production area. Area planted to sunflower increased from 12 million hectares in 1980 to 21 million in 1995. Sunflower yields increased from 1.1 MT/Ha in 1980 to 1.4 MT/Ha in 1991, but have declined somewhat in the last several years (Figure 2.16). Total crush increased from 11.8 MMT in 1980 to 22.6 MMT in 1995. Exports of sunflower seeds declined marginally from 2.0 MMT in 1980 to 1.8 MMT in 1992, but increased to nearly 4.0 MMT in 1995. Figure 2.17 shows trends in area planted for selected producers, while Figure 2.18 compares average yields by country.

Producers. The largest producers of sunflowers are the Former Soviet Union, Argentina, EU, India, China, the United States, and Turkey (Figure 2.19). The Former Soviet Union (FSU) produced 7.3 MMT of sunflowers in 1995, leading all world regions. Argentina and the EU have been the second and third largest producers of sunflower seed from 1980 to 1995. Production in the EU, Argentina, and Pakistan increased threefold in this period, while India increased production from 0.1 MMT in 1980 to 1.5 MMT in 1995.

Exporters. The largest exporters of sunflower seed in the 1980s and early 1990s have been the EU, Argentina, the United States, and (in the early 1990s) the FSU (Figure 2.20). Before the dissolution of the Soviet Union, sunflowers were primarily consumed domestically. After the dissolution, the FSU has increased exports of sunflower seed substantially, with 1.55 MMT of exports in 1995.

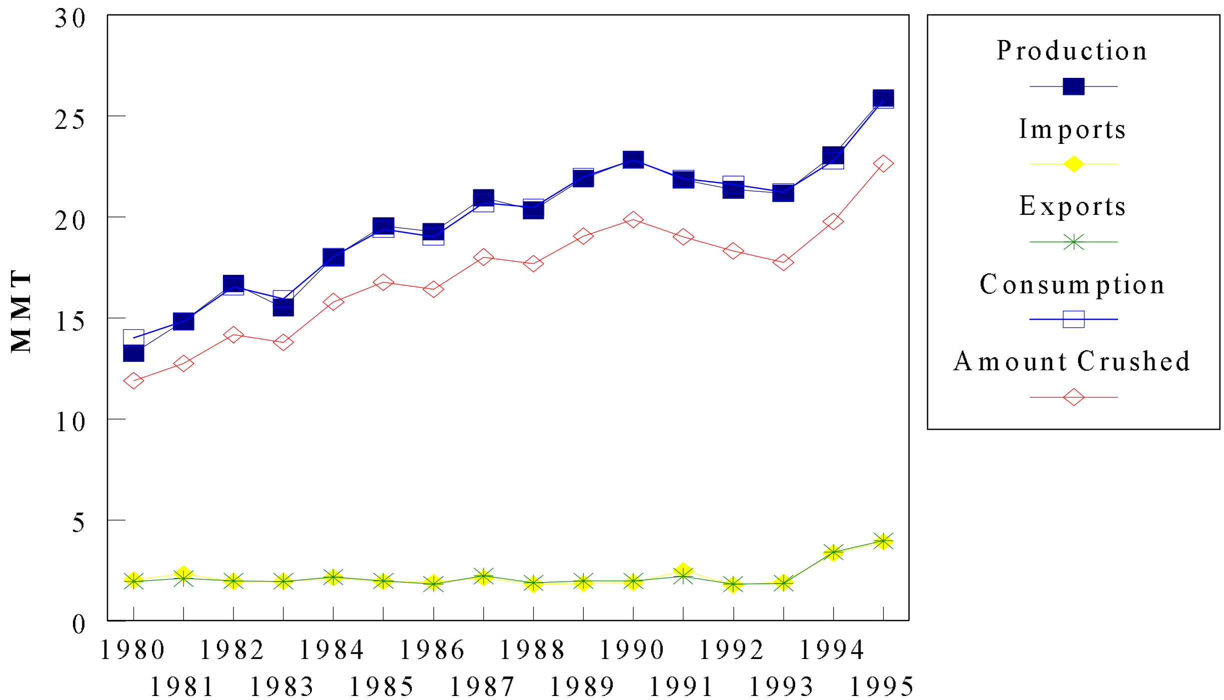

Figure 2.15. World Sunflower Seed Production, Consumption, Exports, and Amount Crushed, 1980-1995

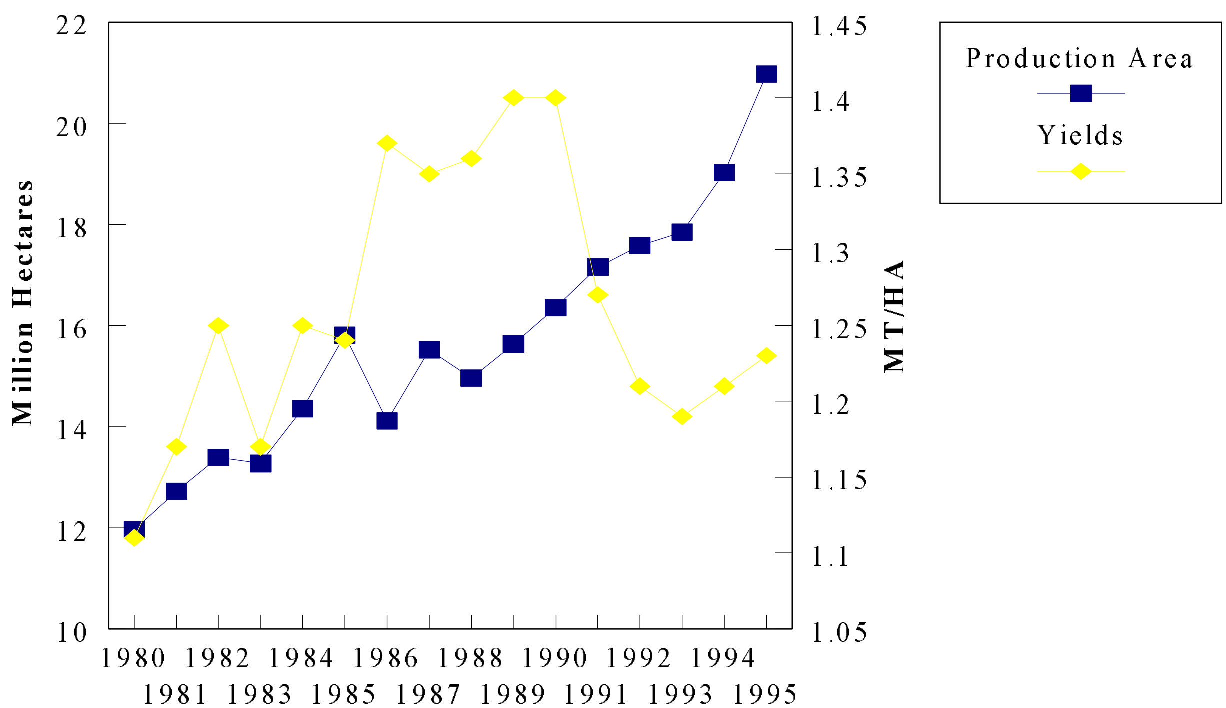

Figure 2.16. World Sunflower Seed Production Area and Yields, 1980-1995

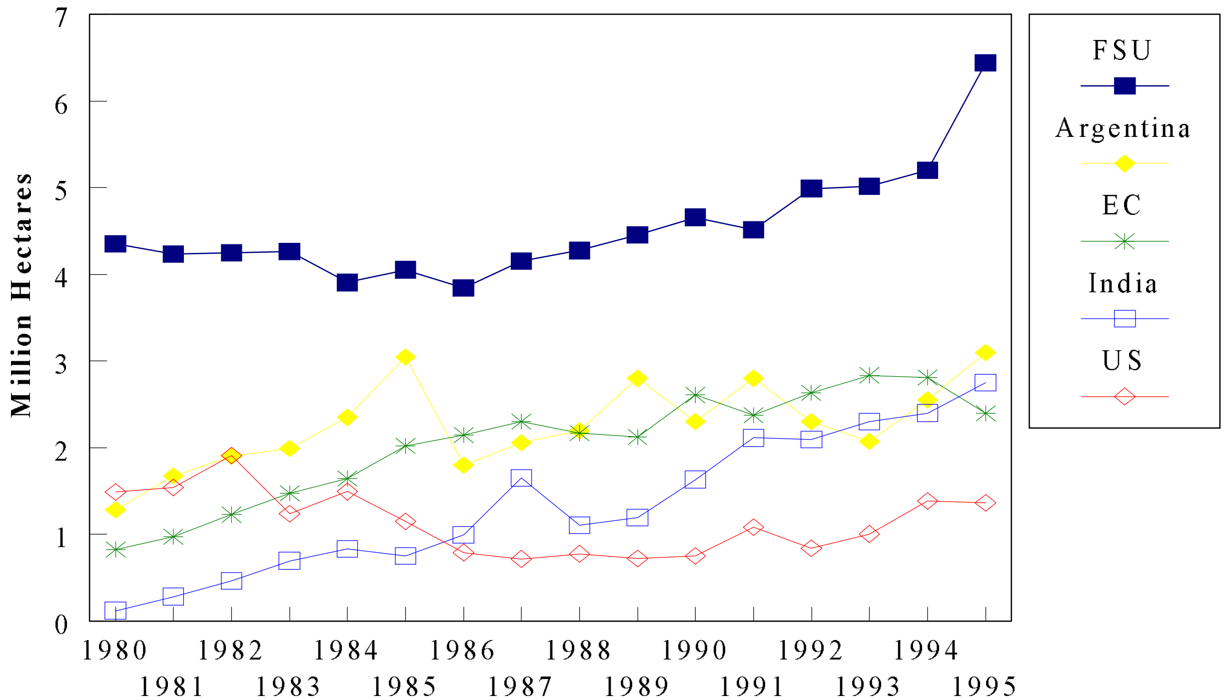

Figure 2.17. Sunflower Seed Area of Production, by Country, 1980-1995

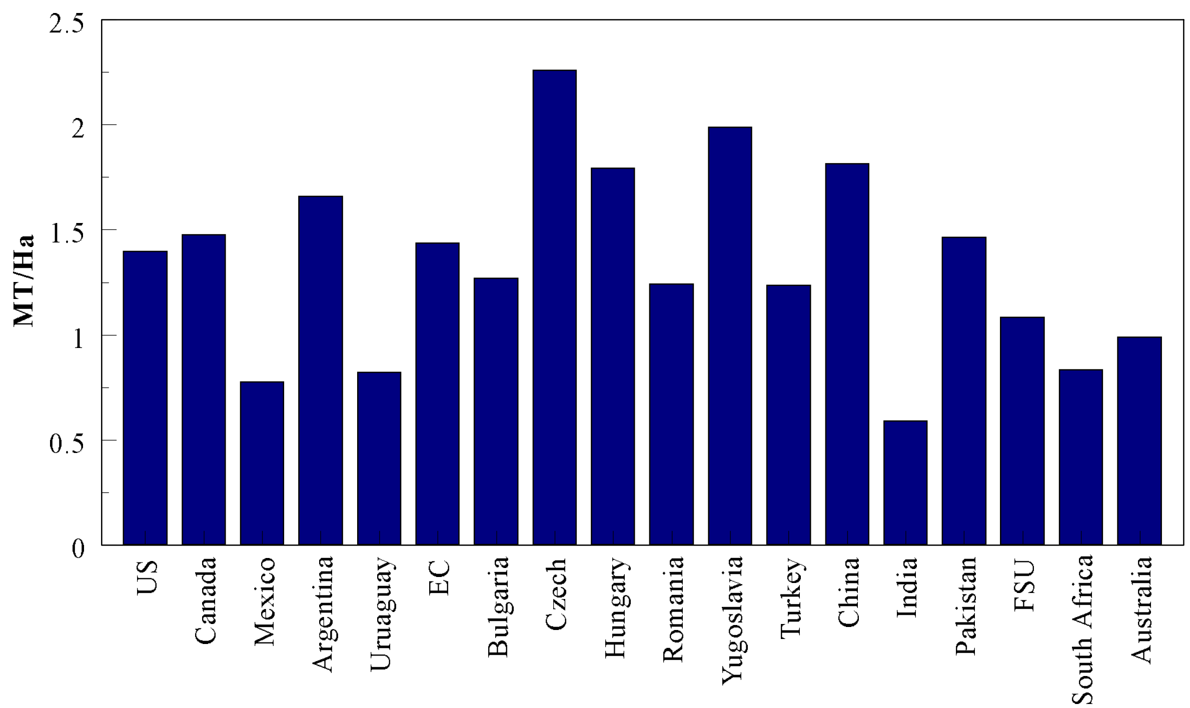

Figure 2.18. Average Sunflower Seed Yields, By Country, 1991-1995

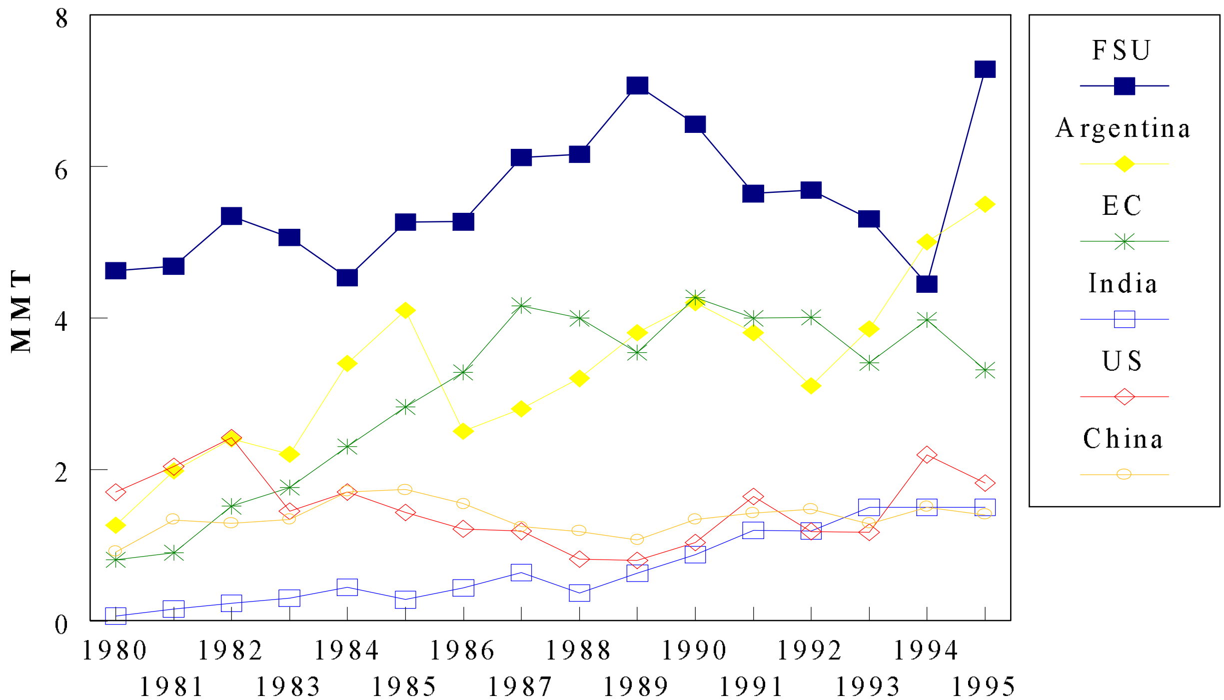

Figure 2.19. Sunflower Seed Production, by Country, 1980-1995

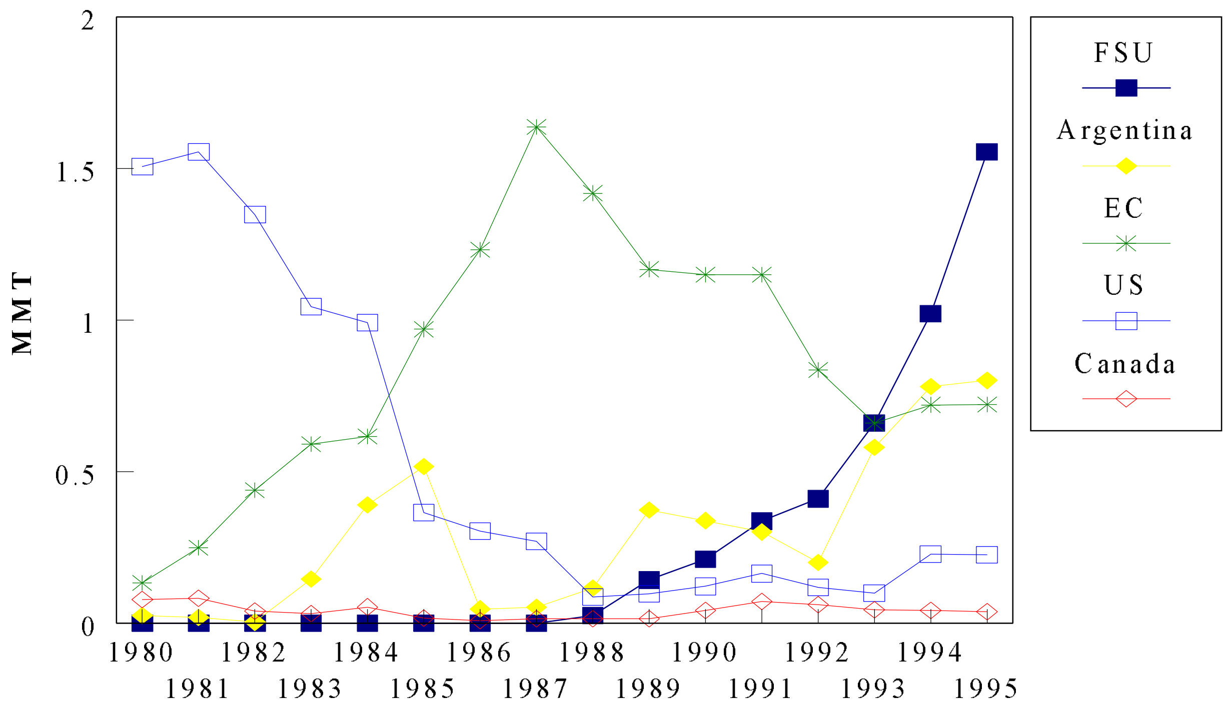

Figure 2.20. Sunflower Seed Exports, by Country, 1980-1995

Importers. World imports of sunflower seed have equaled about 2 MMT from 1980 to 1992, increasing to 3.9 MMT in 1995. The largest sunflower seed importer is the EU, which accounted for 76 percent of world sunflower imports in 1995 (Figure 2.21). Turkey was the second largest importer of sunflower seed in 1994 and 1995, importing 0.58 MMT in 1995. Mexico, Morocco, and Egypt were larger importers in the early 1990s, but have reduced imports from 1990 levels.

Sunflower Oil

World production, consumption, and trade volumes increased from 1980 to 1995 (Figure 2.22). Production of sunflower oil increased from 4.7 MMT in 1980 to nearly 9.0 MMT in 1995. Imports of sunflower oil also increased from 1 MMT in 1980 to 3.4 MMT in 1995.

Producers. The largest producers of sunflower oil are the EU, Argentina, and the FSU. The FSU was the largest producer of sunflower oil through the 1980s. Since 1991, the EU has been the largest producer (Figure 2.23). Sunflower oil production increased in most producing regions from 1980 to 1995. However, Mexico has decreased its production as oil imports have replaced domestic crushing.

Exporters. The largest exporters of sunflower oil are Argentina, the EU, the United States, Turkey, Hungary, and the FSU (Figure 2.24). Argentina has been the largest exporter of sunflower oil since 1981 and accounts for about 41 percent of world exports. The EU increased its exports of sunflower oil throughout the 1980s and early 1990s. EU exports of sunflower oil in 1995 represented 30 percent of world exports. Exports from other countries have fluctuated widely. The FSU increased exports of sunflower oil in the 1980s. Exports peaked at 0.54 MMT in 1988 and have declined to 0.17 MMT in 1995. The United States and Turkey have also become larger exporters of sunflower oil in the 1990s.

Importers. The largest importers of sunflower oil during the 1980s and early 1990s were the EU and FSU (Figure 2.25). Between 1980 and 1995, EU imports increased from 0.32 MMT to 0.68 MMT, while FSU imports increased from 0.15 MMT in 1980 to 0.54 MMT. Imports of the EU and the FSU represent 35.8 percent of world sunflower oil imports. Contrary to the trend in sunflower imports, Mexican imports of sunflower oil increased throughout the 1980s and 1990s. In 1995, Mexico was the fifth largest importer of sunflower oil, importing 0.22 MMT. Other large importers of sunflower oil include Egypt, Turkey, Venezuela, South Africa, and Algeria.

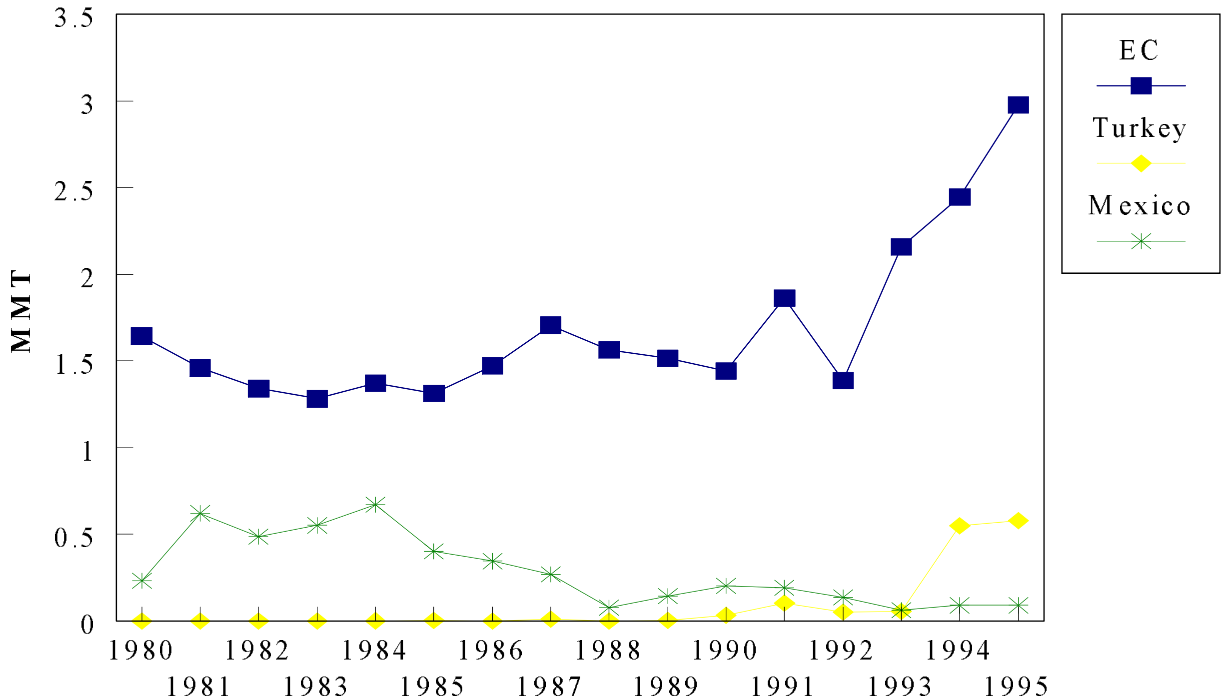

Figure 2.21. Sunflower Seed Imports, by Country, 1980-1995

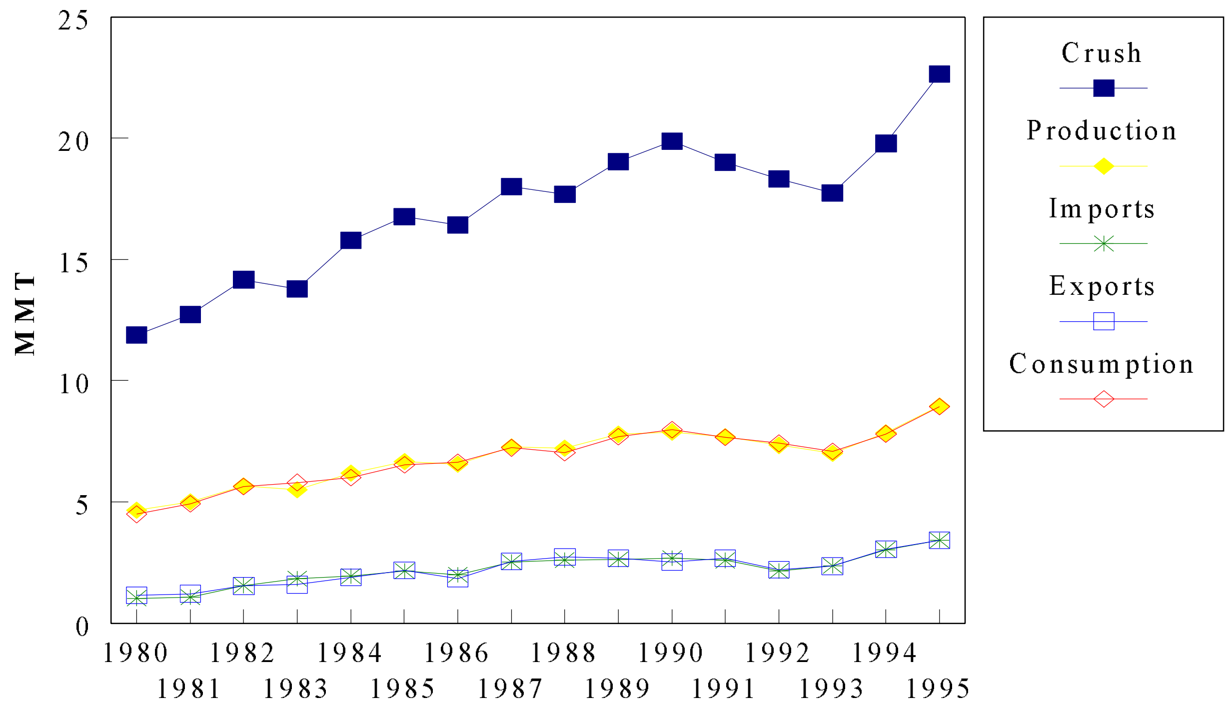

Figure 2.22. World Sunflower Oil Production, Imports, Exports, and Consumption, 1980-1995

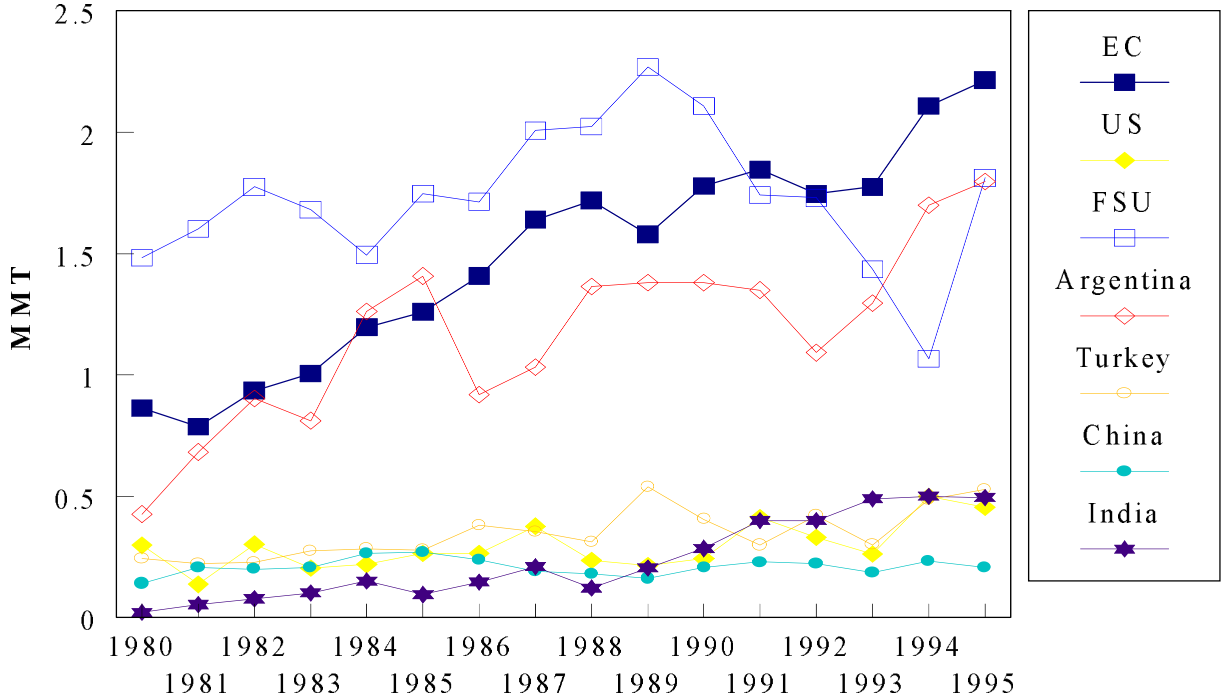

Figure 2.23. Sunflower Oil Production, by Country, 1980-1995

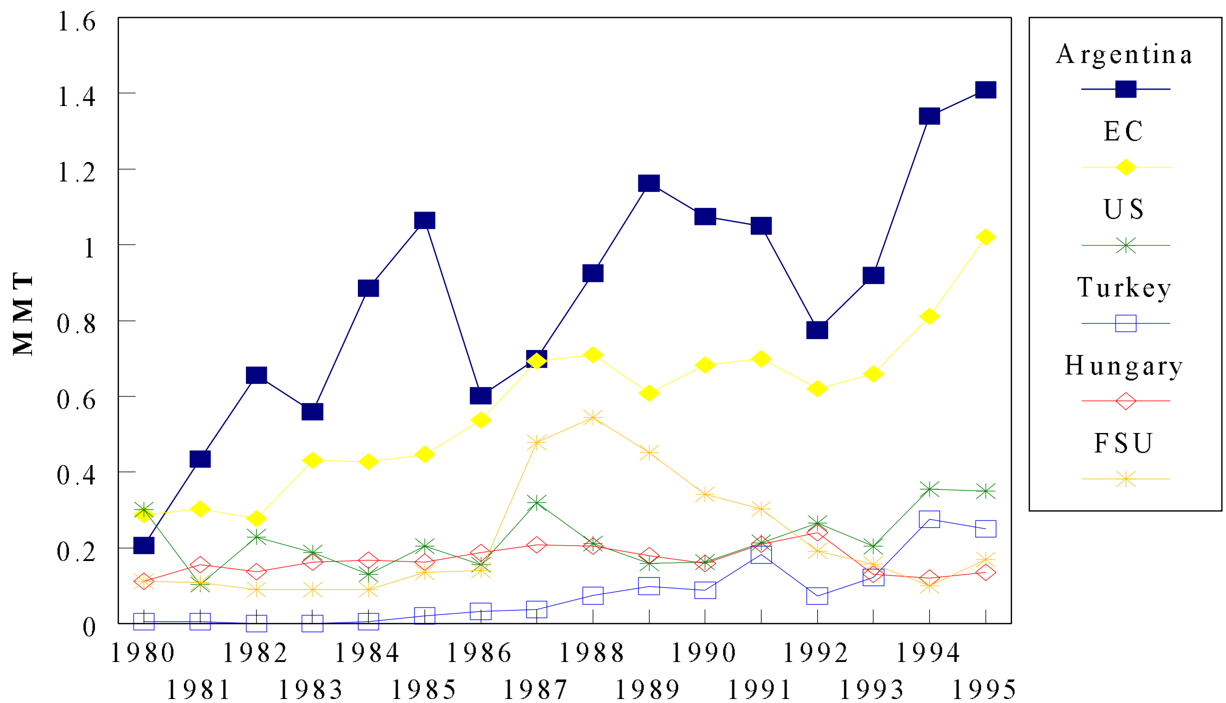

Figure 2.24. Sunflower Oil Exports, by Country, 1980-1995

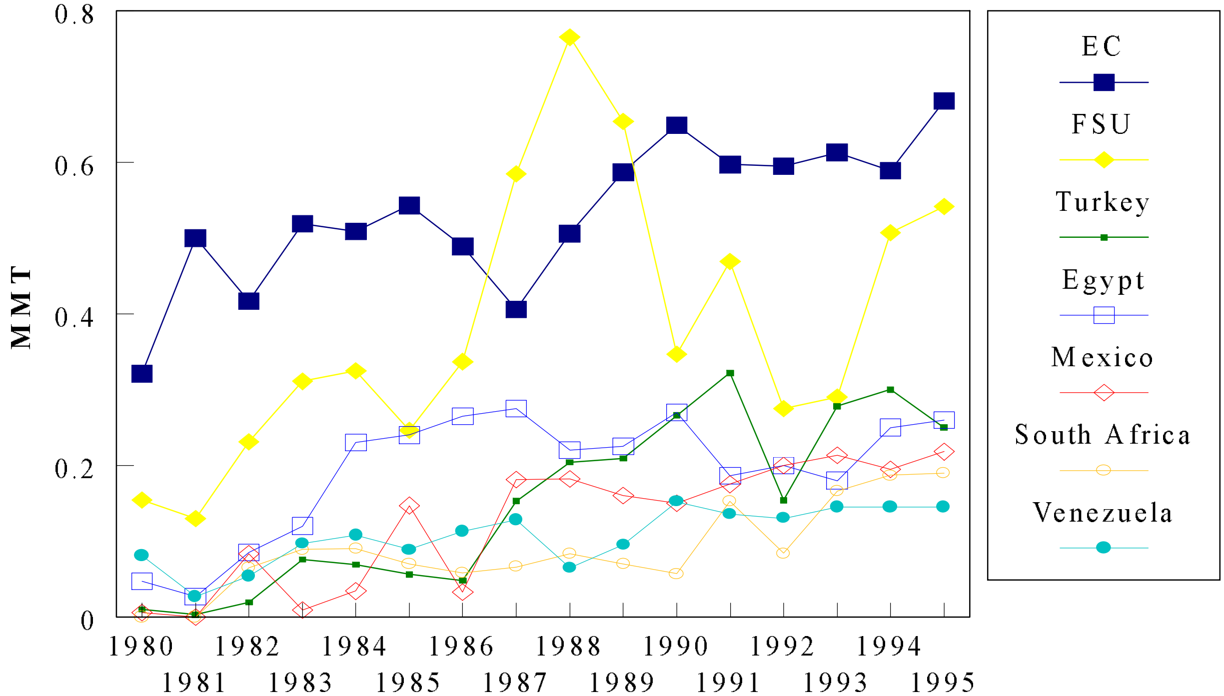

Figure 2.25. Sunflower Oil Imports, by Country, 1980-1995

Agricultural Policies

Agricultural policies and international trade agreements affect trade in sunflower and rapeseed/canola seeds and oils. In many countries, policies are designed to foster local seed production or protect domestic crushing industries. This section reviews agricultural and trade policies and their implications for minor oilseeds.

United States. Historically, oilseeds were excluded from most of the significant features of U.S. commodity programs (e.g., deficiency payments and acreage set-asides). Sunflowers were not considered a program crop until 1990, when minor oilseed provisions were included in the 1990 Farm Bill. These provisions were designed to increase planting flexibility while reducing the traditional bias of commodity programs toward wheat and feed grains. Farmers were allowed to "flex" 15 percent of their crop acreage base into alternative crops like sunflowers without directly affecting program payment levels or base acreage histories. In addition, under the 0/92 option, producers could plant sunflowers or other minor oilseeds on their wheat base and still receive 92 percent of the wheat deficiency payment (McCormick and Hyberg, 1991). In response to these policy changes, sunflower acreage increased from 1.8 million acres in 1987 to an average of 2.6 million acres in 1991-93.

The United States has promoted export sales of sunflowers and sunflower products through several programs, including the Export Enhancement Program (EEP), GSM-102 and 103, PL. 480, and the Sunflower Seed Oil Assistance Program (SOAP). These programs provide credit guarantees (GSM-102 and 103), provisional credit (PL. 480), and commodity/cash bonuses (EEP and SOAP). In fiscal year 1993, 168,242 MT of sunflower oil was exported under GSM-102. Exports of sunflower oil under EEP and PL. 480 since 1990 have been limited. The SOAP program is designed to promote exports of sunflower oil by providing bonuses of commodities (cash from November 1991 on) to targeted importing countries. SOAP was established in 1988 and has been used to export sunflower oil to Algeria, the Dominican Republic, Egypt, El Salvador, the FSU, Guatemala, Mexico, Slovenia, Turkey, and Venezuela. By April 1994, 197,400 MT of sunflower oil had been exported under the SOAP program.

Under recently-passed U.S. farm legislation, provisions affecting the Conservation Reserve Program (CRP), other program crops, and export subsidies will affect the competitiveness of oilseed production. For sunflowers, the elimination of SOAP is certain to have a major impact on domestic crushing and oil exports (Hesley, 1994).

European Community. Throughout the 1980s, the EC maintained high support prices for oilseeds under its Common Agricultural Policy (CAP). This encouraged increases in soybean, sunflower, and rapeseed production. The resulting decline in U.S. soybean exports to Europe led to a protracted dispute over the EC oilseed subsidy regime. The United States initiated two Section 301 filings under GATT. Both panels (in 1989 and 1992) ruled against the EC (Castaneda and Normile, 1994). In response to these GATT rulings (and because of budgetary pressures), the EU undertook a series of CAP reforms, culminating in the Blair House accords reached with the United States in 1992.

The CAP reforms instituted in 1992/93 represent a partial "decoupling" of subsidies from production levels. As a result of the reforms, producer supports are now linked to planted area, rather than production levels. Payments go directly to the farmer rather than to the oilseed processor. EU producer compensation rates are generated for farms based on subsidy levels present in a base period (1986-1990). Compensation payments are calculated to give the same level of support that prevailed in the base period. If world prices decline, compensation payments are increased, and if world prices increase, compensation payments are reduced. World prices are allowed to fluctuate within an 8 percent range before compensation payments are adjusted. For oilseeds, compensation payments are calculated daily. (For other crops, they may be adjusted on a weekly or monthly basis.) Producers receive payments in two installments. The initial payment (provisional) is made at the start of the growing season. The second payment is made after the last reference price is calculated. The final payment is the difference between the provisional payment and the observed reference price.

To receive payments, producers must plant the crop and set aside a portion of their farmland. In 1994, the required set-aside was 15 percent. Oilseeds payments are available only to large-scale farmers (with land sufficient to produce 92 MT of grain). Small-scale producers are exempt from the set-aside requirement, but receive the compensation rate for grains instead of the higher oilseeds compensation rate. Large-scale farmers can produce crops for industrial or non-food use on their set-aside land (OECD).

The Blair House agreement between the EU and the United States resolved the dispute over EU oilseed subsidies. It placed limits on EU oilseeds planted area for producers benefiting from crop-specific oilseed payments. The base area for EU production was set at the average production area from 1989-1991, 5.1 million hectares (Table 2.1). The EU Council set national base areas for individual countries. These national base areas were based on average production area from 1989-1991 and adjusted for changes in production in East Germany, Spain, and Portugal. The maximum planted area allowed is reduced from the base by an annual set-aside rate fixed by the EU Council. The minimum set-aside was 15 percent for 1995. Small-farmer area does not count toward these limits because they do not receive crop-specific oilseed subsidies. Oilseeds planted for industrial are limited separately (one million metric tons, soybean meal equivalent).

Table 2.1. National Base Areas for EU Countries

Country	Base Area	Allowed Area for 1995
	------------thousand hectares-------------	
Germany	928	790
France	1,730	1,470
Italy	542	460
Netherlands	7	687
Belgium	8	6
United Kingdom	385	7
Ireland	5	4
Denmark	236	200
Greece	26	22
Spain	1,168	993
Portugal	93	73
EU (12)	5,128	4,359

Source: Schumacher.

If planted area for individual countries exceeds national base areas, but not EU limits, no cuts in compensation payments will be made. If planted areas exceed the EU limits, then countries exceeding their national base areas will have their compensation payments cut.

Individual countries are also subject to a national base area for main crops, including grains, oilseeds, pulses, and linseed. If applications for compensation payments for a country exceed national base area limits for all crops, then the area eligible for compensation payments for all crops would be reduced (Schumacher). Therefore, countries exceeding their national base area would have oilseeds area reduced.

Argentina. In 1982, Argentina established a differential export tax structure for sunflowers and products. Sunflower seeds, meal, and oil received export taxes of 25 percent, 15 percent, and 10 percent, respectively (Fay). The preferential treatment for sunflower oil increased crush and oil exports. The differential export tax structure was changed frequently in the 1980s. In 1994, Argentina applied a 3.5 percent export tax on sunflower seed and a 2.5 percent export rebate on sunflower oil (Russell, 1994).

Canada. Policy changes in the past decade (GRIP/NISA) have largely focused on stabilization of producer income, with only indirect effects on oilseed acreage (OECD). Canola acreage increased sharply in the early 1990s due to lower prospective returns from wheat and barley, the traditional prairie crops. Between 1990 and 1994, canola acreage more than doubled, from 6.2 to 14.2 million acres.

One of the most significant policy changes has been the elimination of rail subsidies under the Western Grain Transportation Act (WGTA). Formerly, shippers of selected commodities paid a portion of the cost of rail transportation from prairie origins to export position (in Vancouver or Thunder Bay), with the government paying the remainder. This subsidy represented up to 60 percent of the rail cost for qualifying shipments. Canadian producers gained via higher farm-gate prices, especially for wheat and barley. With the elimination of this subsidy (effective 1995), shippers must pay the full cost of rail transportation. This is less significant for canola (which received a small share of the total subsidy) than for cereals. However, the effect may be to alter relative returns in favor of canola production.[4]

Trade Barriers

Several countries have barriers to trade in canola and sunflower seeds and oils. For this study, barriers in effect in 1994 were gathered from several sources, including Country Reports of U.S. Agricultural Attaches, previous studies, and Department of Commerce Country Desks. Many importers of canola and sunflower seeds and oils have import tariffs. These are generally *ad valorem* taxes and range from minimal to high levels. Tariffs on imports of oil are designed to protect domestic crushing or refining industries. Tariffs also vary by the type of oil, sunflower or canola, whether refined or crude, and type of shipment (packaged or bulk).

One of the more important tariffs that affects the international trade in rapeseed and sunflower oil is Japan's 17 yen per kg tariff on imports of crude vegetable oils (canola oil). Japan's tariff scheme is designed to protect its domestic crushing industry; there is no tariff on canola seed. The tariff on vegetable oil imports is specified in yen, and its effect increased in

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[4]For background and analysis of the effects of reforms in Canada's transportation system, see Paddock and Bowen.

1994-95 due to appreciation of the Japanese yen relative to currencies of exporting countries (Dixon).

Barriers to trade also exist for exports of rapeseed and sunflower seeds and oils. Many countries that import seeds or oils have barriers on the export of seed and/or oils. These barriers generally take the form of export duties or differential export tax structures for seeds and oils, but can also include an outright ban on exports. Argentina has a differential export tax structure where exporters are taxed on seed exports and receive a rebate on oil exports. Bulgaria has an export duty for sunflower seeds and oils. Romania has banned exports of all oilseeds.

Barriers are also affected by regional trading alliances. CUSTA, NAFTA, and the Andean Pact alliance among some South American countries are examples of these trading agreements. They generally offer better terms or preference for imports from countries within the alliance.

Canada-U.S. Free Trade Agreement (CUSTA). The free trade agreement between Canada and the United States was designed to eliminate barriers to trade for many commodities, including sunflower and canola seeds and oils. Tariffs on Canadian exports of canola to the United States were reduced from 7 percent to 6 percent to 3.5 percent in 1985, 1987, and 1990, respectively. Under the CUSTA, tariffs were eliminated in 1992. Since 1987, imported canola oil (FOB Decatur) has traded at an average of $0.95 per cwt. lower than soybean oil. This has given canola oil a comparative advantage for some domestic food manufacturers (McCormick and Hoskin, 1991).

NAFTA. The North American Free Trade Agreement (NAFTA) will remove barriers to trade for products, including oilseeds and oilseed products in Canada, Mexico, and the United States. Provisions covering oilseeds, meals, and oils will remove tariffs over a ten-year period and shorten the duration of Mexico's seasonal tariffs for soybean imports. During the phase-in period, tariffs on imports from non-North American countries will still apply. The rules of origin in the agreement will allow all three countries to process oilseeds imported from non-North American countries and export the meal and vegetable oils at NAFTA tariff rates. However, refined vegetable oils produced from crude oil imported from non-NAFTA countries are not eligible for NAFTA tariff rates (Baize).

In 1994, Mexico's import tariffs on rapeseed, sunflower, and cottonseed oils were 10 percent for crude oils and 20 percent for refined oils. Imports of soybean meal into Mexico had a 15 percent import tariff. Furthermore, a 15 percent seasonal tariff on soybean imports to Mexico was applied from August 1 to February 1. Under the NAFTA agreement, the seasonal tariff on soybean imports from the United States and Canada only applies from September 1 to December 31.

The impact of NAFTA will be beneficial for U.S. sunflower oil. Provisions reduce tariffs from their original 10 percent level by 1 percent per year. Other provisions allow for acceleration of tariff reductions. Because Mexico is a major sunflower oil importer, reductions in tariffs would be beneficial for Mexican consumers. U.S. producers should have an advantage due to the proximity of Mexico and lower transportation costs (Kleingartner, 1994).

Discussion has started on expanding NAFTA to include more countries. Chile and Argentina are considered the most likely for near-term inclusion; both countries are producers or potential producers of oilseeds. Features of these agreements could have important implications for the North American oilseed sector.[5]

Uruguay Round of the GATT. The GATT agreement covers three areas: domestic support, market access, and export subsidies. Domestic support levels under the GATT agreement are to be reduced by 20 percent for developed countries and 13 percent for developing countries. Reductions must start in 1995 and be in place by 2000 for developed countries and by 2005 for developing countries. Minimum access levels for developed countries are set at 3 percent of annual domestic consumption, increasing to 5 percent over a six-year period. Import barriers to trade are converted to tariffs and are reduced. The across-the-board reduction in individual tariff barriers was 36 percent for developed countries and 24 percent for developing countries. Total tariff barriers must be reduced by at least 15 percent (10 percent for developing countries). Export subsidies are to be reduced by 2000 for developed countries and by 2005 for developing countries. For developed countries, the volume of subsidized exports and the amount spent on subsidized exports must be reduced by 21 percent and 36 percent, respectively. For developing countries, reductions for the volume of subsidized exports are 14 percent, and budgetary outlays for exports must be reduced by 24 percent. The GATT agreement uses a base period of 1986-1990.

Impacts of GATT on U.S. sunflower oil are ambiguous. Provisions lower tariffs on sunflower oil by 15 percent and reduce usage of EEP, SOAP, and other export promotion subsidies for vegetable oils to 141,299 tons with $14,083,000 in budget outlays (USDA/FAS, *Oilseeds--GATT/Uruguay Round, USDA Factsheet*). However, GATT did not consider differential export tax structures in the Uruguay Round. Thus, Argentina and Brazil, who have export tax differentials that favor oil and meal exports, should benefit from reductions in export subsidies by other exporting countries (Kleingartner, 1994).

Effects of GATT on specific importing countries with trade barriers will be limited. For example, Japan maintains an import tariff on rapeseed oil of 17 yen per kilogram. In May of 1994, this was equivalent to $156 per MT or more than 30 percent of the world price for vegetable oils. The GATT agreement reduces this import tariff by 36 percent by 2000. However, reductions from this high level of the tariff should have a limited impact on canola imports. Further appreciation of the yen would increase the *ad valorem* equivalent of the tariff.

With respect to the EU, the GATT agreement incorporated conditions spelled out in the Blair House Accords. General reductions are applied to tariffs on oilseeds and vegetable oils. Current import tariffs of 5 percent on imports of crude vegetable oils and 10 percent on refined vegetable oils are to be reduced 36 percent to 3.2 percent and 6.4 percent, respectively.

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[5]Disputes over wheat and barley trade have awakened U.S. producers to the importance of trade agreements. In particular, it has been argued that CUSTA favored Canada at the expense of U.S. producer interests.

3. OVERVIEW OF THE SPATIAL EQUILIBRIUM MODEL

The spatial equilibrium model includes sunflower and rapeseed (canola), and their respective products, oil and meal. Other oilseeds are excluded from the analysis.[6] Each of the minor oilseeds and products is homogeneous: meal or oil of a given type (sunflower or rapeseed) is considered of the same quality, wherever it is produced. This is an abstraction from reality, but essential to the logic of the spatial equilibrium model.

The model incorporates considerably more detail for North America than for other regions, particularly in terms of transportation and logistical channels. The United States is divided into 23 oilseed producing regions. These are identified with states, or for North and South Dakota, individual crop reporting districts. Canada is divided into seven producing regions. There are six crushing plant locations in the United States and nine in Canada. In both countries, we select central markets or basing points for oil and meal demand. In the United States, Minneapolis is selected as the center for all oil and meal consumed domestically. Toronto is selected as the center for Canadian oil consumption. Calgary is the center for Canadian canola meal demand, and Winnipeg is the center for Canadian sunmeal demand. Both countries have more than one collection point for offshore exports. U.S. exports are via Duluth, the Gulf, Portland, or Texas (for rail shipment to Mexico). Canadian exports are via Vancouver or Thunder Bay.

Figure 3.1 summarizes the flows of seed and products within North America. From producing regions, seed can be shipped to crushing plants or directly to export positions. No restrictions are placed on cross-border flows; individual crushing plants can draw upon oilseed supplies in both countries, depending on relative transportation costs. Similarly, crushing plants can ship to either U.S. or Canadian markets for oil or meal.

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[6]Prices of soybeans and other oilseeds are considered predetermined, or not influenced by the sunflower or rapeseed markets. This greatly simplifies model specifications because it means that soybean price need not be included as a demand shifter for sunflower and canola.

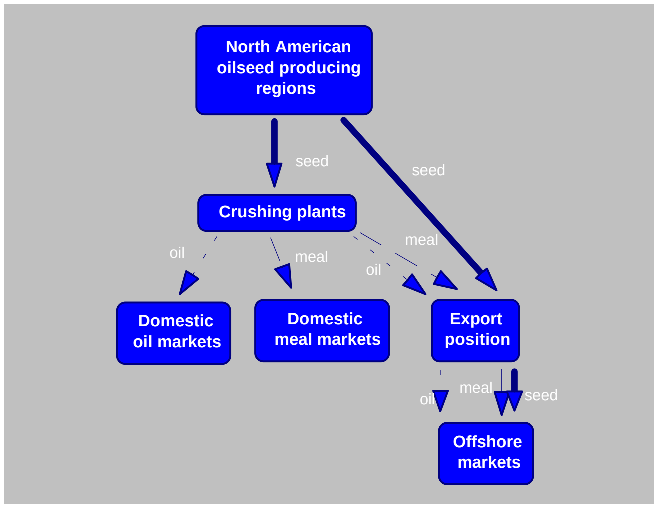
North American oilseed producing regions
seed
seed
Crushing plants
oil
meal
meal
oil
Domestic oil markets
Domestic meal markets
Export position
oil
meal
seed
Offshore markets

Figure 3.1. North American Flows in the Spatial Model

There are 23 regions outside North America. These include the major producing and consuming regions for sunflower and rapeseed. Within these regions, internal shipping costs are not specified. This assumes that prices for oilseeds and products are measured at border points, after payment of relevant import duties, but before internal shipping. World regions are not designated *a priori* as importers or exporters, either with respect to oilseeds or products. Between pairs of regions, the direction of trade is determined by supply and demand conditions, crushing capacities, and a set of arbitrage constraints.

Objective Function

The objective to be maximized is "net social monetary gain" from production and sale of the two oilseeds and their products. This is a variant of the quadratic programming approach to spatial equilibrium. With appropriate specification of constraints (including arbitrage conditions), the optimization problem generates product flows and prices consistent with a competitive trading equilibrium (Takayama and Judge, 1971).

Formally, the objective is

$$
\begin{aligned}
Z \;=\; & \sum_{k}\{\sum_{j} PO_{jk} \cdot QOD_{jk} + \sum_{r} PO_{rk} \cdot QOD_{rk}\} && (\textit{oil revenue}) \\
+ \; & \sum_{k}\{\sum_{j} PM_{jk} \cdot QMD_{jk} + \sum_{r} PM_{rk} \cdot QMD_{rk}\} && (\textit{meal revenue}) \\
- \; & \sum_{k}\{\sum_{i} PS_{ik} \cdot QSPC_{ik} + \sum_{r} PS_{rk} \cdot QSPC_{rk}\} && (\textit{oilseed production costs}) \\
- \; & \sum_{k}\{\sum_{m} cm_{mk} \cdot QSC_{mk} + \sum_{r} cm_{rk} \cdot QSC_{rk}\} && (\textit{crushing costs}) \\
- \; & NATC - ROWTC && (\textit{global transport costs}) \\
- \; & VTAR + VSUB && (\textit{tariffs \& export subsidies})
\end{aligned}
\qquad (1)
$$

Indexes are summarized in Table 3.1. Endogenous variables are capitalized and fixed parameters appear in lowercase. *Z* denotes net social monetary gain. This is revenue from the sale of products less production, crushing, and transportation costs, and adjusted for trade taxes and subsidies. *PO* denotes price of oil ($/mt) and *QOD* the quantity of oil demand (TMT), by type and region. *PM* denotes meal price ($/mt) and *QMD* the quantity of meal demand (TMT). *PS* is the price of seed ($/mt) and *QSPC* the quantity of seed produced and suitable for crushing (TMT). *CM* is the crushing cost parameter ($/mt of seed), and *QSC* is the quantity of seed crushed (TMT). Transportation costs are denoted *NATC* for North American flows and *ROWTC* for the rest of the world. The total value of import tariffs and export subsidies are *VTAR* and *VSUB*, respectively.

Table 3.1. Model Notation: Indexes	
Index	Interpretation
k	oilseed type, k=1,2 (sunflower, rapeseed)
j	North American consumption regions, j=1,2 (U.S., Canada)
r	Regions in rest of world, r=1,...,23
i	North American oilseed producing regions, i=1,...,30
m	North American crushing plants, m=1,...,15
n	North American export ports, n=1,...,6

Oil and Meal Demand

For each consuming region, oil demand is expressed as a linear function of prices

$$QOD_{rk} = a_{rk} + b_{rk}PO_{rk} + c_{rk}PO_{rk'} \qquad \forall\ r,k; \quad k' \neq k \tag{2}$$

where a_{rk} is the intercept, b_{rk} is the direct-price parameter, and c_{rk} is the cross-price parameter for region r and oil type k. These were derived to be consistent with relevant demand elasticities and observed market shares. Similarly, demand for meal is defined

$$QMD_{rk} = f_{rk} + g_{rk}PM_{rk} + h_{rk}PM_{rk'} \qquad \forall\ r,k; \quad k' \neq k \tag{3}$$

where f_{rk}, g_{rk}, and h_{rk} are estimated parameters. Thus, demand for each meal depends on its own price and that of a close substitute (sunflower for canola, and vice versa). Demand specifications for all regions are of the same general form, although we use a different index (j instead of r) for North American markets. The derivation of demand parameters is described more fully in Appendix 1.

Oilseed Supply

For each oilseed-producing region (indexed by i in North America and by r elsewhere), linear supply functions are specified

$$QSP_{rk} = d_{rk} + e_{rk}PS_{rk} \qquad \forall\ r,k \tag{4}$$

where *QSP* is the quantity of seed produced, and *PS* is the seed price. The parameters d_{rk} and e_{rk} are based on regional supply elasticities and market data. These are constructed as follows (suppressing subscripts):

$$e \;=\; \varepsilon\cdot\frac{\overline{QS}}{\overline{PS}}\;; \qquad d \;=\; \overline{QS}(1 \;-\; \varepsilon) \tag{5}$$

where ε is the regional supply elasticity, and prices and quantities are base-period averages.

The model accounts for regional variation in the allocation of production between oil and nonoil uses. This involves a supply adjustment,

$$QSPC_{rk} \;=\; csc_{rk}\cdot\; QSP_{rk} \qquad \forall\; r,k \tag{6}$$

where *QSPC* is the quantity of seed produced and available for crushing (TMT), and *csc* is a fraction less than one. This is based on the proportion of regional production crushed or exported during the base period.[7]

Oilseed Crushing

Oilseeds are converted into products in fixed proportions. Let *QSC* denote the quantity of seed crushed, *QOP* the quantity of oil produced, and *QMP* the quantity of meal produced, all in thousand metric tons. For each region and seed type, these are related as follows:

$$QOP_{rk} \;=\; ocf_{rk} \;\cdot\; QSC_{rk} \qquad \forall\; r,k \tag{7}$$

$$QMP_{rk} \;=\; mcf_{rk} \;\cdot\; QSC_{rk} \qquad \forall\; r,k \tag{8}$$

where *ocf* is the oil conversion factor (extraction rate) and *mcf* the meal conversion factor.

The subscripts for conversion factors suggest that these parameters vary by region, but the variation is limited to several major producing regions. In most of the world, conversion factors are assumed to be identical (Table 3.2). Unique conversion factors are used for China, south Asia, and the former Soviet Union, regions with oil extraction rates that are significantly lower than in North America or Europe.[8]

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[7]Remaining categories of utilization, e.g., food, feed and waste, are not specified in the model. By assumption, all production available for crushing (QSPC) is crushed, either domestically or after export.

[8]Regional differences in oil extraction rates are largely due to differences in varieties grown. The extraction rates listed in Table 3.2 for China, South Asia, and the FSU are from PS&D. Extraction rates for other regions are assumed to be identical to those for North America.

Table 3.2. Product Conversion Factors				
Region	Sunflower		Rapeseed	
	ocf (oil)	mcf (meal)	ocf (oil)	mcf (meal)
China	0.22	0.58	0.33	0.62
South Asia	0.36	0.45	0.33	0.66
FSU	0.42	0.48	0.25	0.59
All other	0.42	0.48	0.41	0.57

Source: USDA, *PS&D View*.

These differences pose a conceptual problem. It would be implausible for seeds with different extraction rates to have the same price (after adjusting for shipping costs). However, in the context of the spatial model, all traded goods are considered homogeneous. The problem is overcome by imposing restrictions on trade flows. In particular, China and South Asia are not allowed to trade rapeseed or sunflower, while the former Soviet Union is not allowed to trade rapeseed.[9] The restrictions do not conflict with observed trade patterns: in fact, these regions do not export or import significant amounts of seed. By limiting the extent of seed trade, we allow the model to retain differences in extraction rates. This ensures more accurate projections of global supply balances for oil and meal.

The conversion factors in Table 3.2 imply differences in the amount of waste generated in crushing sunflower and rapeseed. In most of the world, 10 percent (by weight) of sunflower is wasted, versus 2 percent for rapeseed.

Within North America, crushing activities are constrained by annual plant capacities. These capacities, measured in TMT of seed, are specified for oilseeds individually (*cap*) and in combination (*tcap*) as follows:

$$QSC_{mk} \le cap_{mk} \qquad \forall \; m,k \tag{9}$$

$$\sum_k QSC_{mk} \le tcap_m \qquad \forall \; m \tag{10}$$

Daily crushing capacities for North American plants are reproduced in Table 3.3. To convert these into annual capacities, we assume that the plants operate 320 days/year. All U.S. plants and two plants in Canada are allowed to crush either type of seed; the other plants in Canada are limited to canola, based on current practices.

[9]No restrictions are placed on trade in products (oil and meal) in these regions.

Table 3.3. Crushing Capacities, North American Plants

Location	Daily Plant Capacity, TMT Seed		
	Sunflower	Canola	Total†
Red Wing, MN	1,500	1,500	1,500
Enderlin, ND	2,000	2,000	2,000
Goodland, KS	500	500	500
Riverside, ND	2,000	2,000	2,000
Culbertson, MT	300	300	300
Velva, ND	0	1,000	1,000
Hamilton, ONT	0	600	600
Altona, MAN	965	965	965
Harrowby, MAN	0	600	600
Nipawin, SAS	0	600	600
Fort Sask., SAS	0	700	700
Windsor, ONT	2,400	2,400	2,400
Lloydminster, ALB	0	720	720
Lethbridge, ALB	0	700	700
Sexsmith, ALB	0	700	700

† Total available capacity for sunflower and canola
Source: Agriculture Canada, *Oilseeds Sector Profile, 1994*, and U.S. industry sources.

For regions outside North America, data on crushing capacities (by oilseed type) were not available. Hence, quantities crushed are constrained to be no more than 120 percent of observed levels during the base period:

$$QSC_{rk} \leq 1.2 \cdot bcap_{rk} \qquad \forall \ r,k \tag{11}$$

where *bcap* is the actual quantity crushed in 1994.

Flows and Material Balance

Table 3.4 provides a listing of flow variables for seed and products. The model provides greater detail about North American flows than for other world regions.

Table 3.4. Listing of Flow Variables

Variable	Commodity	From	To
XS1(i,m,k)	Seed	NA producing region	NA crushing plant
XS2(i,n,k)	Seed	NA producing region	NA export port
XS3(n,r,k)	Seed	NA export port	World region
XS(r,r̃,k)	Seed	World Region	World region
XO1(m,j,k)	Oil	NA crushing plant	NA domestic market
XO2(m,n,k)	Oil	NA crushing plant	NA export port
XO3(n,r,k)	Oil	NA export port	World region
XO(r,r̃,k)	Oil	World region	World region
XM1(m,j,k)	Meal	NA crushing plant	NA domestic market
XM2(m,n,k)	Meal	NA crushing plant	NA export port
XM3(n,r,k)	Meal	NA export port	World region
XM(r,r̃,k)	Meal	World region	World region

At each stage of the North American marketing system (producer, processor, domestic product markets and export), flows are constrained by material balance equations. Thus, oilseed shipments from producing regions cannot exceed available supplies:

$$\sum_m XS1_{imk} + \sum_n XS2_{ink} \leq QSPC_{ik} \qquad \forall\ i,k \tag{12}$$

The sum of shipments received by plants equals the quantity of seed crushed:

$$\sum_i XS1_{imk} = QSC_{mk} \qquad \forall\ m,k \tag{13}$$

In North American domestic markets, demand quantities for oil and meal are tied to shipments from crushing plants to domestic basing points:

$$QOD_{jk} = \sum_{m} XO1_{mjk} \qquad \forall\ j,k \tag{14}$$

$$QMD_{jk} = \sum_{m} XM1_{mjk} \qquad \forall\ j,k \tag{15}$$

All seed shipments received in North American ports are exported to overseas markets:

$$\sum_{i} XS2_{ink} = \sum_{r} XS3_{nrk} \qquad \forall\ n,k \tag{16}$$

Similar constraints apply for exports of meal and oil from North American ports:

$$\sum_{m} XM2_{mnk} = \sum_{r} XM3_{nrk} \qquad \forall\ n,k \tag{17}$$

$$\sum_{m} XO2_{mnk} = \sum_{r} XO3_{nrk} \qquad \forall\ n,k \tag{18}$$

In overseas markets, total imports of seed, meal, and oil (by type) are specified to include inflows from North American ports and other foreign origins:

$$QSI_{rk} = \sum_{n} XS3_{nrk} + \sum_{r'} XS_{r'rk} \qquad \forall\ r,k;\ r' \neq r \tag{19}$$

$$QMI_{rk} = \sum_{n} XM3_{nrk} + \sum_{r'} XM_{r'rk} \qquad \forall\ r,k;\ r' \neq r \tag{20}$$

$$QOI_{rk} = \sum_{n} XO3_{nrk} + \sum_{r'} XO_{r'rk} \qquad \forall\ r,k;\ r' \neq r \tag{21}$$

where *QSI* denotes total seed imports, *QMI* total meal imports, and *QOI* total oil imports. Total exports from these regions are defined:

$$QSE_{rk} = \sum_{r'} XS_{rr'k} \qquad \forall\ r,k \tag{22}$$

$$QME_{rk} = \sum_{r'} XM_{rr'k} \qquad \forall\ r,k \tag{23}$$

$$QOE_{rk} = \sum_{r'} XO_{rr'k} \qquad \forall\ r,k \tag{24}$$

where *QSE* denotes seed exports, *QME* meal exports, and *QOE* oil exports. Using these definitions, the supply-demand balances for oilseeds and products are specified as follows:

$$QSPC_{rk} + QSI_{rk} = QSC_{rk} + QSE_{rk} \qquad \forall\ r,k \tag{25}$$

$$QMP_{rk} + QMI_{rk} = QMD_{rk} + QME_{rk} \qquad \forall\ r,k \tag{26}$$

$$QOP_{rk} + QOI_{rk} = QOD_{rk} + QOE_{rk} \qquad \forall\ r,k \tag{27}$$

In each case, supply includes domestic production and imports. Demand includes domestic consumption (or crushing) and exports. This assumes no change in stocks; all production and trade are for current use.

Transportation Costs

Within North America, total transportation costs for oilseeds, meal, and oil are given by

$$
\begin{aligned}
NATC = & \sum_i \sum_k \Big\{ \sum_m XS1_{imk} \cdot ts1_{imk} + \sum_n XS2_{ink} \cdot ts2_{ink} \Big\} \\
& + \sum_m \sum_k \Big\{ \sum_j XO1_{mjk} \cdot to1_{mj} + \sum_n XO2_{mnk} \cdot to2_{mn} \Big\} \\
& + \sum_m \sum_k \Big\{ \sum_j XM1_{mjk} \cdot tm1_{mjk} + \sum_n XM2_{mnk} \cdot tm2_{mnk}
\end{aligned}
\tag{28}
$$

where *ts1* and *ts2* are unit costs of shipping seed ($/mt); *to1* and *to2* are unit costs of shipping oil ($/mt), and *tm1* and *tm2* are unit costs of shipping meal ($/mt) between specified points.

For flows outside North America, transportation costs are given by

$$
\begin{aligned}
ROWTC = & \sum_r \sum_k \Big\{ \sum_n XS3_{nrk} \cdot ts3_{nrk} + \sum_{r'} XS_{r'rk} \cdot ts_{r'rk} \Big\} \\
& + \sum_r \sum_k \Big\{ \sum_n XO3_{nrk} \cdot to3_{nr} + \sum_{r'} XO_{r'rk} \cdot to_{r'r} \Big\} \\
& + \sum_r \sum_k \Big\{ \sum_n XM3_{nrk} \cdot tm3_{nrk} + \sum_{r'} XM_{r'rk} \cdot tm_{r'rk} \Big\}
\end{aligned}
\tag{29}
$$

where *ts3*, *to3*, and *tm3* are unit shipping costs (ocean freight) from North American ports, and *ts*, *to*, and *tm* are unit shipping costs from other origins. For oil, unit shipping costs are the same for sunflower and rapeseed. However, costs of shipping seed and meal differ by type (sun or rape) due to differences in product densities. Details on the estimation of shipping cost parameters can be found in Appendix 2.

Tariffs and Export Subsidies

For each world region, the model applies the average level[10] of *ad valorem* tariffs observed during 1993-94. Let *asi* denote the *ad valorem* tariff rate for seed imports, *ami* the rate for meal imports, and *aoi* the rate for oil imports. These are fractions applied to the delivered price, inclusive of ocean freight. (Values for individual regions are listed in Appendix Tables A1.2 and A1.3). The total value of import tariffs, aggregated over world regions, is given by[11]

$$ITAR = \sum_r \{\frac{asi_{rk}}{(1+asi_{rk})} \cdot PS_{rk} \cdot QSI_{rk} + \frac{aoi_{rk}}{(1+aoi_{rk})} \cdot PO_{rk} \cdot QOI_{rk} + \frac{ami_{rk}}{(1+ami_{rk})} \cdot PM_{rk} \cdot QMI_{rk}\} \quad (30)$$

In addition to import tariffs, the model incorporates *ad valorem* export duties, as levied by individual regions during the base period. Let *ase* denote *ad valorem* rate for seed exports, *aoe* the rate for oil exports, and *ame* the rate for meal exports.[12] The total value of export duties is

$$ETAR = \sum_r \{ase_{rk} \cdot PS_{rk} \cdot QSE_{rk} + aoe_{rk} \cdot PO_{rk} \cdot QOE_{rk} + ami_{rk} \cdot PM_{rk} \cdot QME_{rk}\} \quad (31)$$

The total value of all tariffs (import and export), given by

$$VTAR = ITAR + ETAR \quad (32)$$

---

[10]For regions comprised of several importing countries, we use the trade-weighted average of tariff rates. In selected cases (e.g., China and Hong Kong, identified as "China" in model output), we used tariff rates for the largest consuming country.

[11]Prices of oilseeds and products (*PS*, *PO*, and *PM*) for each region include applicable import duties. To obtain landed prices *before* payment of duty, these prices must be divided by 1 + the *ad valorem* tariff rate.

[12]Argentina applies export subsidies for sunflower oil and meal. Thus, *aoe* and *ame* are negative for southern South America. See Appendix Table A1.2.

is contained in the objective function, and is deducted as a cost along with transportation. In contrast, export subsidies under the U.S. SOAP program (if applicable) enter as a credit in the objective function. The value of these subsidies is given by

$$VSUB = \sum_{r} \sum_{n(us)} XO3_{nr(sunf)} \cdot SOAP_{r} \tag{33}$$

where *n(us)* signifies shipments from U.S. ports and $SOAP_r$ is the unit value ($/mt) of U.S. subsidies for sunflower oil in targeted markets. (As noted in Section 4, these subsidies are nil in the base case simulation.)

To prevent the re-export of subsidized sunflower oil, imports under the SOAP program are restricted to be no larger than domestic oil consumption in targeted markets:

$$\sum_{r} \sum_{n(us)} XO3_{nr(sunf)} \leq QOD_{r(sunf)} \qquad (SOAP\ \ recipients) \tag{34}$$

Arbitrage Conditions

To ensure that conditions of competitive spatial equilibrium are satisfied, it is necessary to impose arbitrage conditions. By constraining price relationships between regions and products, these prevent profitable arbitrage opportunities from occurring in model solutions.

Ten arbitrage conditions apply to flows within or from North America. These include three constraints each for oilseeds, meal, and oil, and a constraint for oilseed crushing. All are indexed by region and type (sunflower or rapeseed).

The first two conditions are for oilseed prices received by North American producers:

$$PS_{ik} \geq PS_{mk} - ts1_{imk} \qquad \forall i,m,k \tag{35}$$

$$PS_{ik} \geq PS_{nk} - ts2_{ink} \qquad \forall i,n,k \tag{36}$$

These ensure that producer prices (region i) are at least as great as prices at crushing locations (region m) or export ports (region n), after adjustment for transportation. Oilseed prices at North American ports, in turn, are no lower than prices in foreign destinations, adjusted for ocean freight and foreign import tariffs:

$$(PS_{nk} + ts3_{nrk})(1 + asi_{rk}) \geq PS_{rk} \qquad \forall n,r,k \tag{37}$$

Similar constraints apply for North American exports of meal and oil. An additional adjustment is made for SOAP subsidies, if applicable:

$$(PM_{nk} + tm3_{nr})(1 + ami_{rk}) \geq PM_{rk} \qquad \forall n,r,k \tag{38}$$

$$\begin{aligned} (PO_{nk} + to3_{nr})(1 + aoi_{rk}) &\geq PO_{rk} \qquad (non\text{-}SOAP) \\ (PO_{nk} + to3_{nr} - SOAP_{r})(1 + aoi_{rk}) &\geq PO_{rk} \qquad (SOAP) \end{aligned} \tag{39}$$

The latter constraint raises the U.S. sunflower oil price, measured at U.S. ports, relative to foreign markets.

At crushing plants, product prices must be at least as high (after adjustment for transport) as prices at export ports or domestic markets. Thus, for meal, we have

$$PM_{mk} \geq PM_{nk} - tm2_{mnk} \qquad \forall m,n,k \tag{40}$$

$$PM_{mk} \geq PM_{jk} - tm1_{mjk} \qquad \forall m,j,k \tag{41}$$

and similarly for oil:

$$PO_{mk} \geq PO_{nk} - to2_{mn} \qquad \forall m,n,k \tag{42}$$

$$PO_{mk} \geq PO_{jk} - to1_{mj} \qquad \forall m,j,k \tag{43}$$

Crushing margins are constrained as follows:

$$PS_{mk} \geq ocf_{k} \cdot PO_{mk} + mcf_{k} \cdot PM_{mk} - cm_{mk} \qquad \forall m,k \tag{44}$$

where *ocf* is the oil conversion factor, *mcf* is the meal conversion factor, and *cm* is the (constant) marginal cost of crushing 1 ton of seed. This implies an absence of profit opportunities in oilseed crushing.

For the rest of the world, arbitrage constraints are less numerous because of the absence of internal, intra-regional flows. Pricing constraints are applied for seed, oil, meal, and crushing margins:

$$[PS_{rk} \cdot (1 + ase_{rk}) + ts_{rr'k}](1 + asi_{r'k}) \geq PS_{r'k} \qquad \forall\ k;\ r' \neq r \tag{45}$$

$$[PO_{rk} \cdot (1 + aoe_{rk}) + to_{rr'k}](1 + aoi_{r'k}) \geq PO_{r'k} \qquad \forall r,r',k;\ r' \neq r \tag{46}$$

$$[PM_{rk} \cdot (1 + ame_{rk}) + tm_{rr'k}](1 + ami_{r'k}) \geq PM_{r'k} \qquad \forall r,r',k;\ r' \neq r \tag{47}$$

$$PS_{rk} \geq ocf_k \cdot PO_{rk} + mcf_k \cdot PM_{rk} - cm_{rk} \qquad \forall r,k \tag{48}$$

Constraint (45) applies only in regions where seed trade is allowed; it does not apply to several regions with low oil extraction rates (see Table 3.2). The constraints ensure that prices received by exporters of oilseeds, oil, or meal are at least as great as the best available market, after adjustment for transportation and trade taxes. However, crushing margins are only sufficient to cover production costs.

Data Sources and Lacunae

International production and consumption data for 1994 were taken from the USDA database, *PS&D View*. Data for individual countries were aggregated to match our regional definitions. Import and export tariffs are based on information collected from Agricultural Attaché Country Reports (USDA-FAS), Department of Commerce country desks, and several industry sources. Tariffs and subsidies for individual regions are listed in Appendix 1, along with other model parameters.

Demand parameters for oil and meal, by region, were developed using published elasticity estimates and base-period consumption levels. Overall demand elasticities for oil and meal were taken from Sullivan et al., "A Database for Trade Liberalization Studies." That source provides estimates of demand elasticities by region for major agricultural commodities. However, oilseeds and products are divided into just two categories, soybean and "other."

To derive separate parameters for sunflower and rapeseed, we combined the published demand elasticities for *other oilseeds* (oil or meal) with an assumed elasticity of substitution. In the base case, we assume that the elasticity of substitution between sunflower and rapeseed (oil or meal) is twice the overall demand elasticity in each region. This ensures that sunflowers and rapeseed are substitutes, with positive cross-price terms in the demand functions. Results of alternative assumptions (higher and lower elasticities of substitution) are reported in Appendix 1 for comparison.

Regional supply elasticities for oilseeds are likewise taken from Sullivan et al. These are for *other oilseeds* (not soybeans) and are applied equally to sunflower and canola production. Within individual regions, therefore, differences in supply schedules (between sunflower and rapeseed) are due entirely to differences in base-period prices and quantities.

Information on crushing costs (parameter cm_{rk}) by type and region were not available. For North America and selected world regions with advanced crushing technology (i.e., EU, other western Europe, southern South America) we assume crushing costs of $25/metric ton of seed. Elsewhere, we assume crushing costs of $50/ton, based on conversations with industry experts.

U.S. production data were gathered from the USDA *Oil Crops Situation and Outlook Report*, state-level statistics services, and the U.S. Canola Association. North Dakota canola acres by crop reporting district were obtained from the state ASCS office. Canadian statistics (by crop district) were from Statistics Canada. Crushing capacities in Canada were obtained from Agriculture Canada *Oilseeds Sector Profile*, 1994. Capacities for U.S. plants are from Lilleboe, Bangsund (personal communication) and other industry sources. Oilseed prices, used to estimate supply schedules for North American regions, were obtained from the Canadian Grains Council *Statistical Handbook*, USDA *Agricultural Prices*, and *North Dakota Agricultural Statistics* for 1994. Average 1994 prices for oil and meal (sunflower and canola), used to estimate demand schedules, were calculated from published quotes in *Milling and Baking News* and *Feedstuffs*.

Prices of minor oilseeds, oil, and meal were generally unavailable for markets outside North America. In place of (unobserved) regional prices, we used published prices at European ports to fit supply and demand schedules.[13] Further information on demand estimation is provided in Appendix 1.

4. SIMULATION RESULTS

In this section, results of alternative model simulations are reported and discussed. The base case provides a standard for comparison and is reported in greater detail. Other scenarios include shifts in U.S. sunflower acres, retention of the SOAP program, implementation and extension of NAFTA, global trade liberalization under GATT, elimination of tariffs in specific import markets (China and Japan), EU supply reductions; and changes in Argentina's export subsidy regime.

Base Case

The base-case simulation reflects 1994 levels of production and demand, tariffs and subsidies (which vary substantially by region), and estimated shipping costs. Although the model was fit with available data, our base-case projections do no entirely agree with observed patterns of some production, consumption, or trade. Comparisons of model projections with actual data are made for model validation (Table 4.1). For most world regions, projections of seed production and crush and oil production and consumption are close to observed 1994 levels. For the world as a whole, model projections of seed, oil, and meal production are all within 6 percent of observed levels. Projections of crush and consumption (oil and meal) are within 3 percent of actual world levels.

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[13]Rotterdam for sunflower seed, sunflower meal, sunflower oil, and rapeseed oil; Hamburg for rapeseed and rapeseed meal (USDA/FAS *Oilseeds: World Markets and Trade*, July 1995).

Table 4.1. Ratios of Predicted to Historical Values in Base Case

	Sunflower						Canola					
	Seed		Oil		Meal		Seed		Oil		Meal	
	Production	Crush	Production	Consumption	Production	Consumption	Production	Crush	Production	Consumption	Production	Consumption
USA	0.979	1.089	1.143	0.998	1.059	0.552	0.91	1.331	1.623	1.117	1.427	0.701
Canada	1.153	0	0	1.033	0	1.249	0.934	0.896	0.918	1.166	0.875	0.821
Mexico	0.922	1.003	1.221	0.992	1.102	1.069	0*	1.042	1.068	1.063	1.072	1.072
Cen. America	0*	0*	0*	1.066	0*	0*	0*	0*	0*	1.169	0*	0*
Caribbean	0*	0*	0*	1.02	0*	1.084	0*	0*	0*	1.075	0*	0*
Venezuela	1	0	0*	0.944	0	0.966	0*	0*	0	0	0*	0*
E. S. America	1	0	0*	0.972	0	1.151	0.944	0	0	0	0*	0*
S. S. America	0.875	1.039	1.064	1.106	1.186	1.385	1.054	1.054	0.53	0.91	0.601	0.601
W. S.America	1	0	0	1.049	0	1	0.933	0	0	0	0	1
East Europe	0.956	0.958	0.977	1.011	0.975	1.012	0.976	0.938	0.949	1.049	0.901	1.018
O. W. Europe	0.963	0	0	1.024	0	1.04	0.975	1.105	1.115	1.088	1.059	1.01
Turkey	0.976	1.036	1.037	1	1.308	1.072	0.982	0	0	1.003	0	1.01
Egypt	0.965	0	0	1.015	0	1.041	0*	0*	0	1.036	0*	0*
Middle East	0.968	0.21	0.203	1.011	0.232	1.022	0.979	0	0	0	0*	0*
North Africa	0.986	0.962	1.154	1.001	1.086	0.848	0.992	0	0	1.002	0	1.096
West Africa	0*	0*	0*	1.019	0*	0*	0*	0*	0*	1.025	0*	0*
East Africa	1	0	0	1.016	0	1.025	0.976	0	0	1.03	0	1.031
South Africa	0.97	1.2	1.201	0.934	1.177	1.095	0	0*	0	1.136	0*	0*
China	0.951	0.978	0.98	0.98	0.979	1.036	0.988	0.974	0.972	0.945	0.974	1.029
Japan	0*	0.0*	0*	0.844	0*	0*	0.948	1.031	1.008	1.008	1.02	1.054
S.E. Asia	1		0	1.058	0	1.078	0*	0*	0	1.127	0*	1.145
South Asia	0.939	0.939	0.955	0.904	0.948	1.002	0.964	0.956	0.951	0.925	0.949	1.032
Oceania	0.867	1.01	1.016	1.054	0.9	1.02	0.923	0	0	1.075	0	1.018
FSU	0.975	1.093	1.098	1	1.371	1.04	0.94	0.949	0.964	1.017	0.953	1.002
EU	0.914	0.874	0.895	1.005	0.764	1.052	0.938	1.038	1.057	1.12	1.008	1.012
World	0.938	0.971	0.992	0.997	1	1.017	0.957	0.979	0.991	1.014	0.965	1.001

*Historical levels and model predictions are both zero.

Notable discrepancies for the United States include projections of sunflower meal consumption (55 percent of the observed 1994 level) and canola crush (133 percent).[14] Such discrepancies, wide in percentage terms, are of small consequence if actual 1994 levels are small relative to world totals (as with U.S. canola crush).

Tables 4.2 through 4.7 summarize base-case quantities and prices (model projections) by world region. The United States produces 2,041 TMT of sunflower seed, or about 10.6 percent of the world total. Two-thirds of U.S. sunflower production is crushed domestically, and the remainder is exported. The U.S. producer price (a weighted average of U.S. producing regions) is $258/MT in the base case (Table 4.2), equivalent to $11.70/cwt. U.S. production of sunflower oil is 572 TMT, or about 7.4 percent of world production (Table 4.3). About 77 percent of this oil is exported.

Canada produces 6,411 TMT of canola seed in the base case, or 24.4 percent of the world total (Table 4.5). About 34 percent of this production is crushed domestically, and 66 percent is exported, largely to Japan and the EU. Of Canada's canola oil production, 38 percent is exported to the United States, and the remainder is consumed domestically (Table 4.6). Canada also exports large amounts of canola meal to the United States (Table 4.7).

Figures 4.1 through 4.6 provide an overview of global market shares in the base case. For comparison, each figure shows actual 1994 trade shares (upper panel) along with model projections (lower panel). To facilitate comparison, actual trade volumes in 1994 exclude intra-EU trade.

In model projections, exports of sunflower seed are dominated by the United States (32 percent), the Former Soviet Union (27 percent), and Eastern Europe (21 percent), while imports are dominated by the European Union (61 percent) and Turkey (28 percent) (Figure 4.1). In sunflower oil, exports are dominated by southern South America (i.e., Argentina and Chile; 76 percent) and the United States (24 percent), while imports are well-diversified (Figure 4.2). In sunflower meal, southern South America is the leading exporter (68 percent) and EU is the leading importer (80 percent) (Figure 4.3).

Canada accounts for 90 percent of world exporters of canola/rapeseed in base case projections (Figure 4.4). Importers of rapeseed include Japan (42 percent), the EU (37 percent), and Mexico (10 percent). Exports of canola/rape oil are divided between the EU (74 percent) and Canada (26 percent) (Figure 4.5). Leading oil importers include China (33 percent), the United States (26 percent), and north Africa (9 percent). Canada is the leading exporter of canola meal (41 percent), and the EU is the leading importer (40 percent), followed by the United States (31 percent). Projections also show U.S. exports of canola meal; this involves transshipment of Canadian meal through the port of Duluth.

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[14]Projected U.S. sunflower meal production is higher than the actual 1994 level; however, much of this production is exported (see Table 4.4). While some U.S. canola production is exported, the United States is a net importer of canola seed (Table 4.5).

Table 4.2. Base Case Solutions - Sunflower Seed*					
	Production	Crush	Exports	Imports	Price
Region/Country	-----------------------------TMT-----------------------------				-----$/MT----
USA	2041	1361	680	0	227
Canada	128	0	128	0	236
Mexico	0	87	0	87	268
Cen. America	0	0	0	0	260
Caribbean	0	0	0	0	262
Venezuela	15	0	15	0	258
E. S. America	60	0	60	0	258
S. S. America	4332	4332	0	0	261
W. S. America	3	0	3	0	253
East Europe	2184	1745	439	0	261
O. W. Europe	69	0	69	0	278
Turkey	597	1202	0	604	267
Egypt	20	0	20	0	262
Middle East	5	5	0	0	250
North Africa	38	38	0	0	289
West Africa	0	0	0	0	258
East Africa	47	0	47	0	257
South Africa	487	620	0	133	290
China	1038	1038	0	0	162
Japan	0	0	0	0	227
S.E. Asia	99	0	99	0	244
South Asia	1406	1406	0	0	269
Oceania	92	92	0	0	247
FSU	3360	2789	572	0	265
EU	3184	4492	0	1308	281
World	19207	19207	2133		
Crush Weighted Average Price					260

*Prices in North America are at producer level; port prices for other regions.

Table 4.3. Base Case Solutions - Sunflower Oil*					
	------------------------------TMT------------------------------				-----$/MT----
Region/Country	Production	Consumption	Exports	Imports	Price
USA	572	130	442	0	557
Canada	0	32	0	32	581
Mexico	37	227	0	190	629
Cen. America	0	23	0	23	592
Caribbean	0	41	0	41	618
Venezuela	0	144	0	144	683
E. S. America	0	24	0	24	652
S. S. America	1820	415	1405	0	571
W. S. America	0	5	0	5	607
East Europe	733	733	0	0	610
O. W. Europe	0	68	0	68	573
Turkey	505	505	0	0	638
Egypt	0	267	0	267	589
Middle East	2	320	0	318	582
North Africa	16	239	0	223	630
West Africa	0	3	0	3	565
East Africa	0	16	0	16	574
South Africa	261	377	0	117	696
China	228	228	0	0	682
Japan	0	11	0	11	773
S.E. Asia	0	40	0	40	580
South Asia	506	506	0	0	748
Oceania	39	54	0	15	576
FSU	1171	1480	0	308	635
EU	1887	1887	0	0	599
World	7775	7775	1847		
Consumption Weighted Average Price					626

*Prices in North America are for domestic consumption; port prices for other regions.

Table 4.4. Base Case Solutions - Sunflower Meal*					
	Production	Consumption	Exports	Imports	Price
Region/Country	---------------------------------TMT---------------------------				-----$/MT----
USA	653	306	347	0	95
Canada	0	21	0	21	93
Mexico	42	50	0	8	112
Cen. America	0	0	0	0	108
Caribbean	0	43	0	43	109
Venezuela	0	7	0	7	123
E. S. America	0	18	0	18	100
S. S. America	2080	126	1954	0	96
W. S. America	0	1	0	1	105
East Europe	838	930	0	93	115
O. W. Europe	0	29	0	29	114
Turkey	577	419	158	0	103
Egypt	0	48	0	48	106
Middle East	2	215	0	212	115
North Africa	18	36	0	17	154
West Africa	0	0	0	0	100
East Africa	0	21	0	21	108
South Africa	298	276	22	0	100
China	602	554	48	0	108
Japan	0	0	0	0	106
S.E. Asia	0	49	0	49	115
South Asia	633	518	115	0	111
Oceania	44	50	0	6	115
FSU	1339	1094	245	0	102
EU	2156	4471	0	2315	113
World	9281	9281	2888		
Consumption Weighted Average Price					110

*Prices in North America are for domestic consumption; port prices for other regions.

Table 4.5. Base Case Solutions - Canola Seed*					
	--------------------------------TMT--------------------------				-----$/MT----
Region/Country	Production	Crush	Exports	Imports	Price
USA	181	606	46	471	246
Canada	6411	2195	4262	46	240
Mexico	0	495	0	495	268
Cen. America	0	0	0	0	264
Caribbean	0	0	0	0	265
Venezuela	0	0	0	0	263
E. S. America	0	0	0	0	256
S. S. America	28	28	0	0	319
W. S. America	1	0	1	0	260
East Europe	1244	1120	124	0	265
O. W. Europe	639	639	0	0	269
Turkey	0	0	0	0	259
Egypt	0	0	0	0	258
Middle East	0	0	0	0	252
North Africa	0	0	0	0	278
West Africa	0	0	0	0	256
East Africa	17	0	17	0	250
South Africa	0	0	0	0	250
China	6662	6662	0	0	258
Japan	0	1969	0	1969	276
S.E. Asia	0	0	0	0	259
South Asia	5254	5254	0	0	267
Oceania	276	0	276	0	256
FSU	189	189	0	0	176
EU	5280	7025	0	1745	269
World	26182	26182	4724		
Crush Weighted Average Price					260

*Prices in North America are at producer level; port prices for other regions.

Table 4.6. Base Case Solutions - Canola Oil*					
	--------------------------------TMT---------------------------				-----$/MT----
Region/Country	Production	Consumption	Exports	Imports	Price
USA	248	591	0	343	561
Canada	900	557	343	0	579
Mexico	203	255	0	52	585
Cen. America	0	1	0	1	542
Caribbean	0	16	0	16	582
Venezuela	0	0	0	0	528
E. S. America	0	0	0	0	529
S. S. America	12	20	0	8	614
W. S. America	0	0	0	0	530
East Europe	459	459	0	0	575
O. W. Europe	262	260	2	0	516
Turkey	0	5	0	5	610
Egypt	0	1	0	1	538
Middle East	0	0	0	0	530
North Africa	0	120	0	120	609
West Africa	0	55	0	55	538
East Africa	0	20	0	20	534
South Africa	0	19	0	19	579
China	2198	2637	0	439	682
Japan	807	807	0	0	605
S.E. Asia	0	79	0	79	541
South Asia	1734	1734	0	0	712
Oceania	0	106	0	106	548
FSU	47	102	0	54	580
EU	2880	1905	975	0	517
World	9751	9751	1320		
Consumption Weighted Average Price					617

*Prices in North America are for domestic consumption; port prices for other regions.

Table 4.7. Base Case Solutions - Canola Meal*					
	Production	Consumption	Exports	Imports	Price
Region/Country	------------------------------TMT----------------------------				-----$/MT----
USA	345	677	391	723	128
Canada	1251	308	943	0	129
Mexico	282	282	0	0	138
Cen. America	0	0	0	0	142
Caribbean	0	0	0	0	140
Venezuela	0	0	0	0	139
E. S. America	0	0	0	0	133
S. S. America	16	16	0	0	162
W. S. America	0	1	0	1	146
East Europe	639	457	182	0	140
O. W. Europe	364	464	0	100	145
Turkey	0	1	0	1	136
Egypt	0	0	0	0	133
Middle East	0	0	0	0	124
North Africa	0	27	0	27	137
West Africa	0	0	0	0	130
East Africa	0	3	0	3	131
South Africa	0	0	0	0	125
China	4130	3851	279	0	134
Japan	1122	1401	0	279	137
S.E. Asia	0	74	0	74	132
South Asia	3468	2949	519	0	124
Oceania	0	173	0	173	142
FSU	111	117	0	6	137
EU	4004	4931	0	927	143
World	15733	15733	2314		
Consumption Weighted Average Price					136

*Prices in North America are for domestic consumption; port prices for other regions.

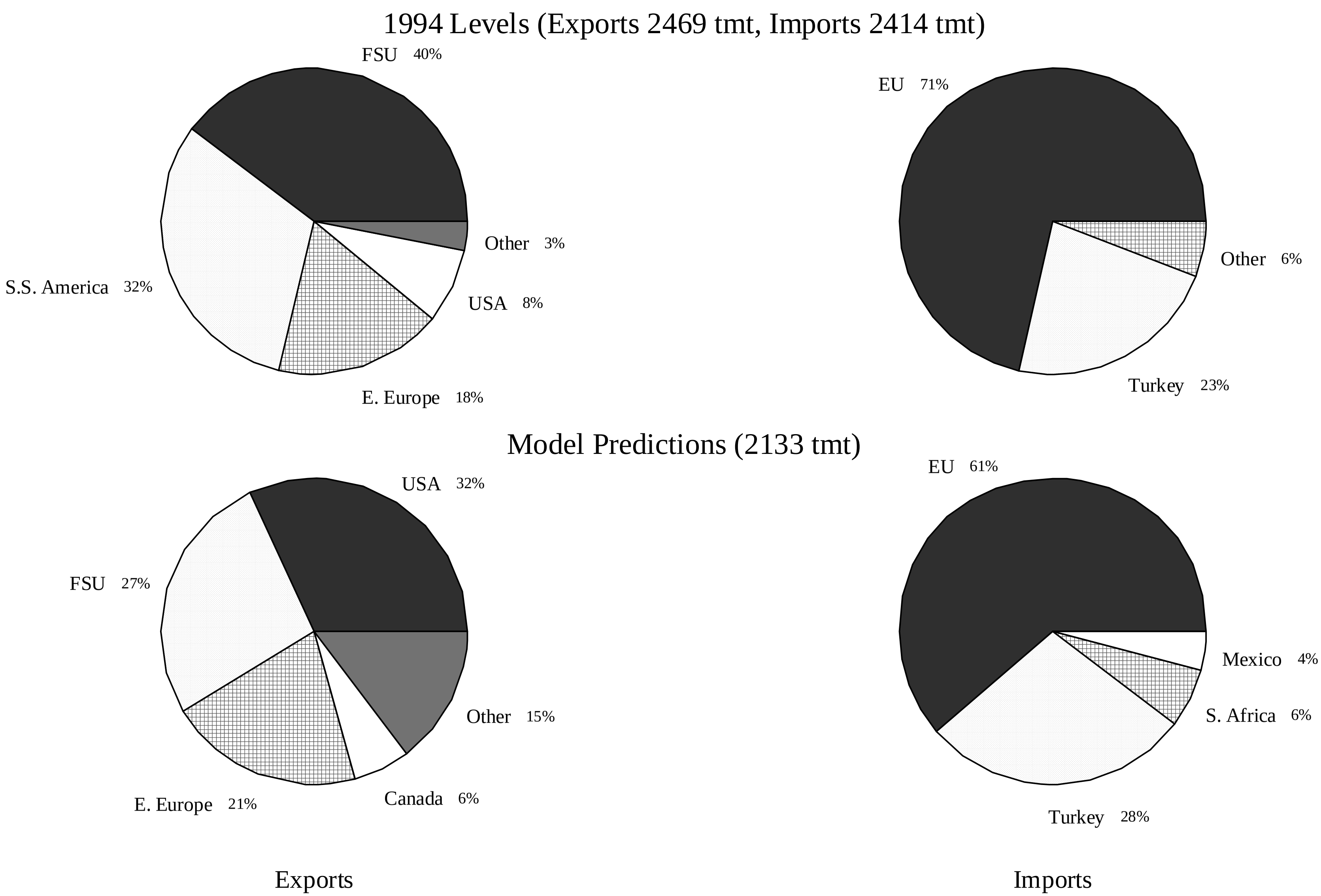

Figure 4.1. Shares of Major Sunflower Seed Trading Regions

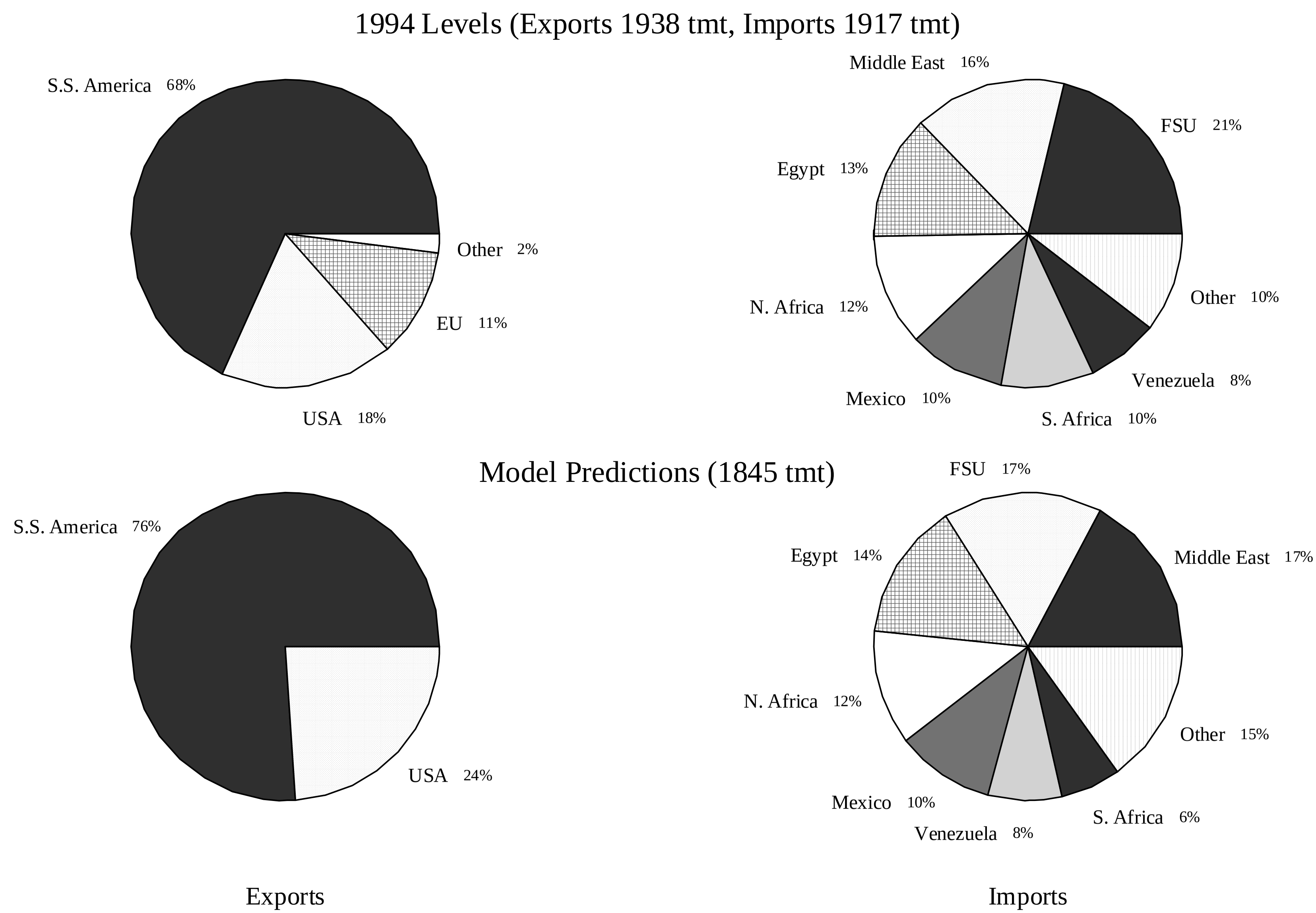

Figure 4.2. Shares of Major Sunflower Oil Trading Regions

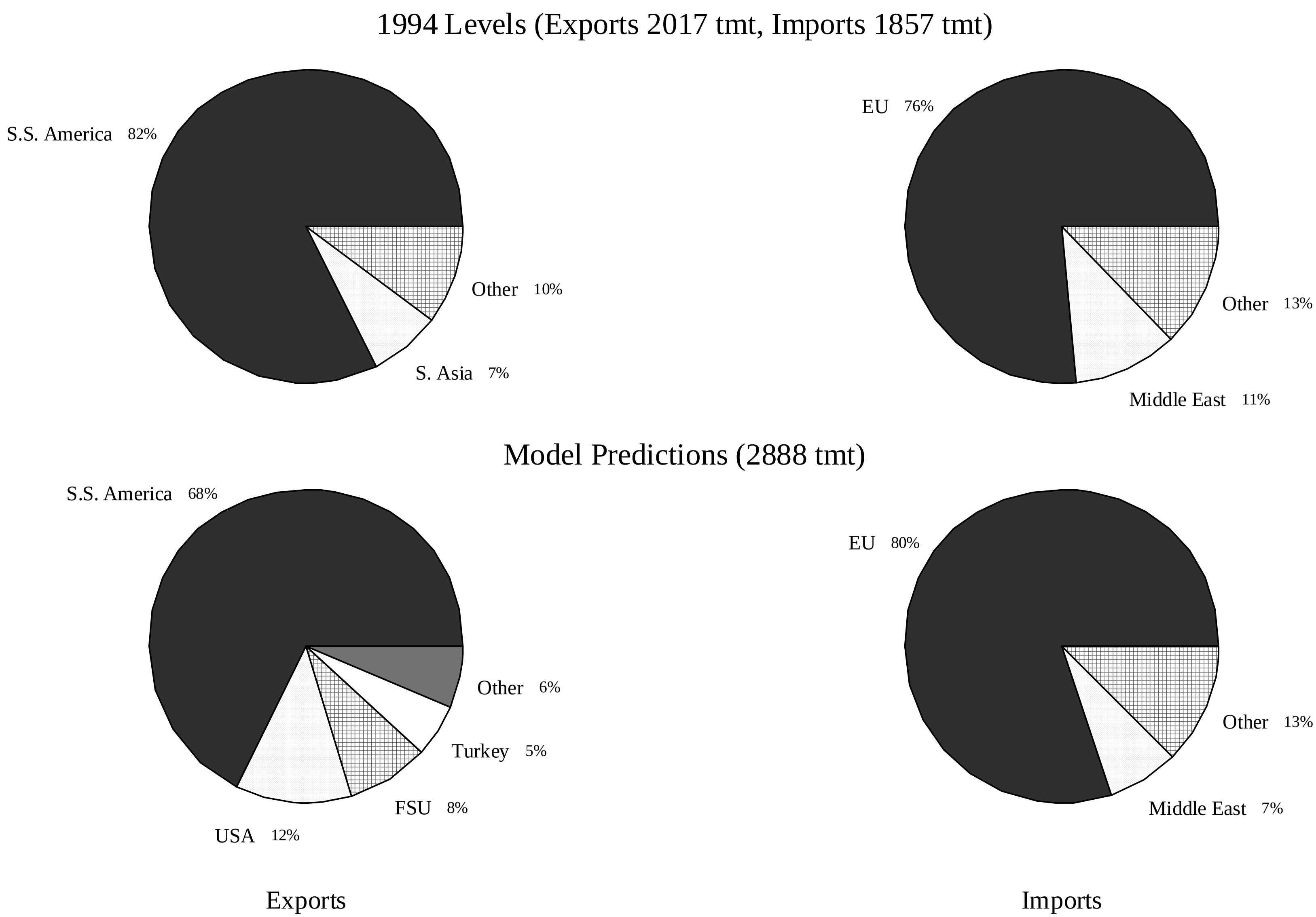

Figure 4.3. Shares of Major Sunflower Meal Trading Regions

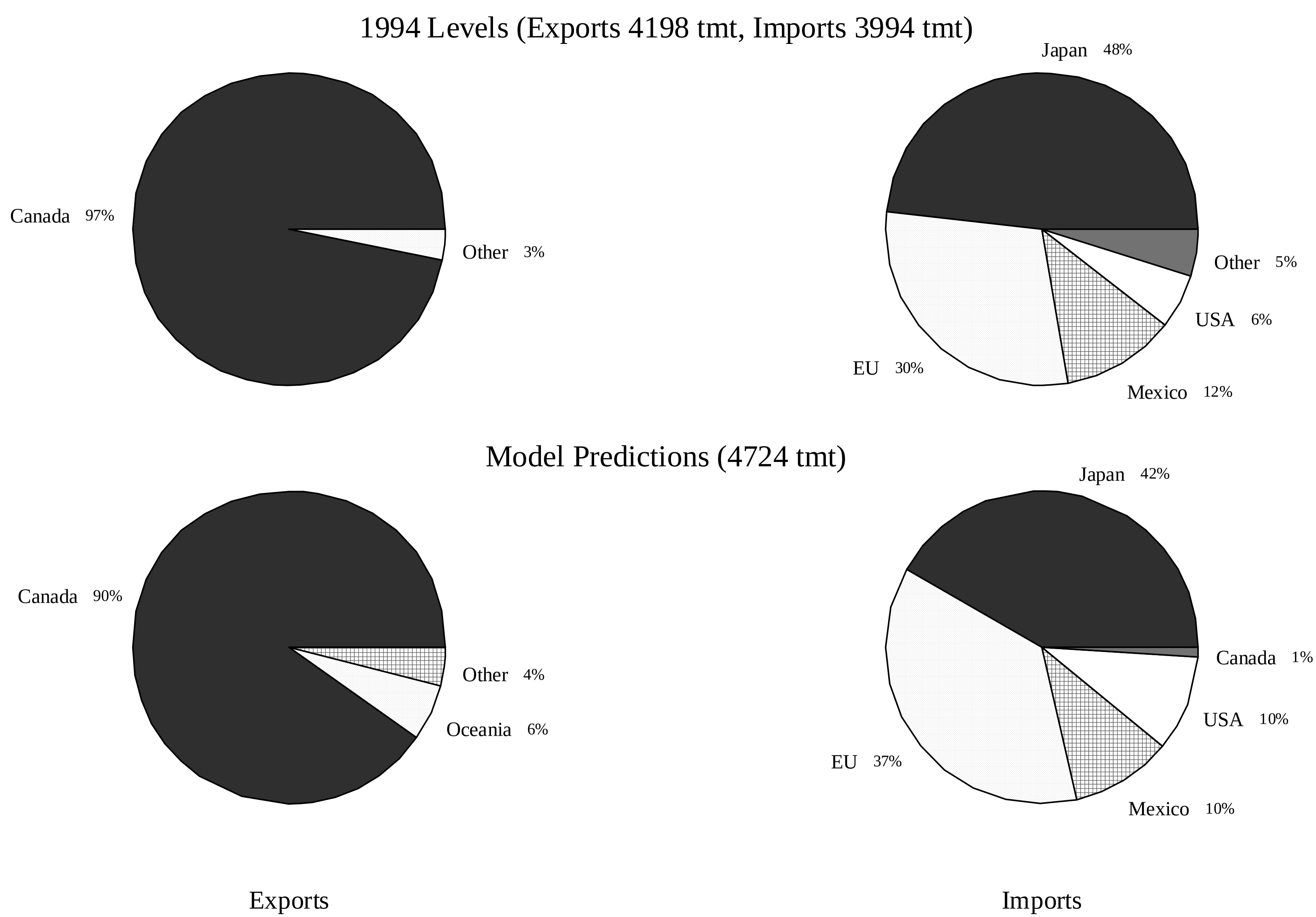

Figure 4.4. Shares of Major Canola Seed Trading Regions

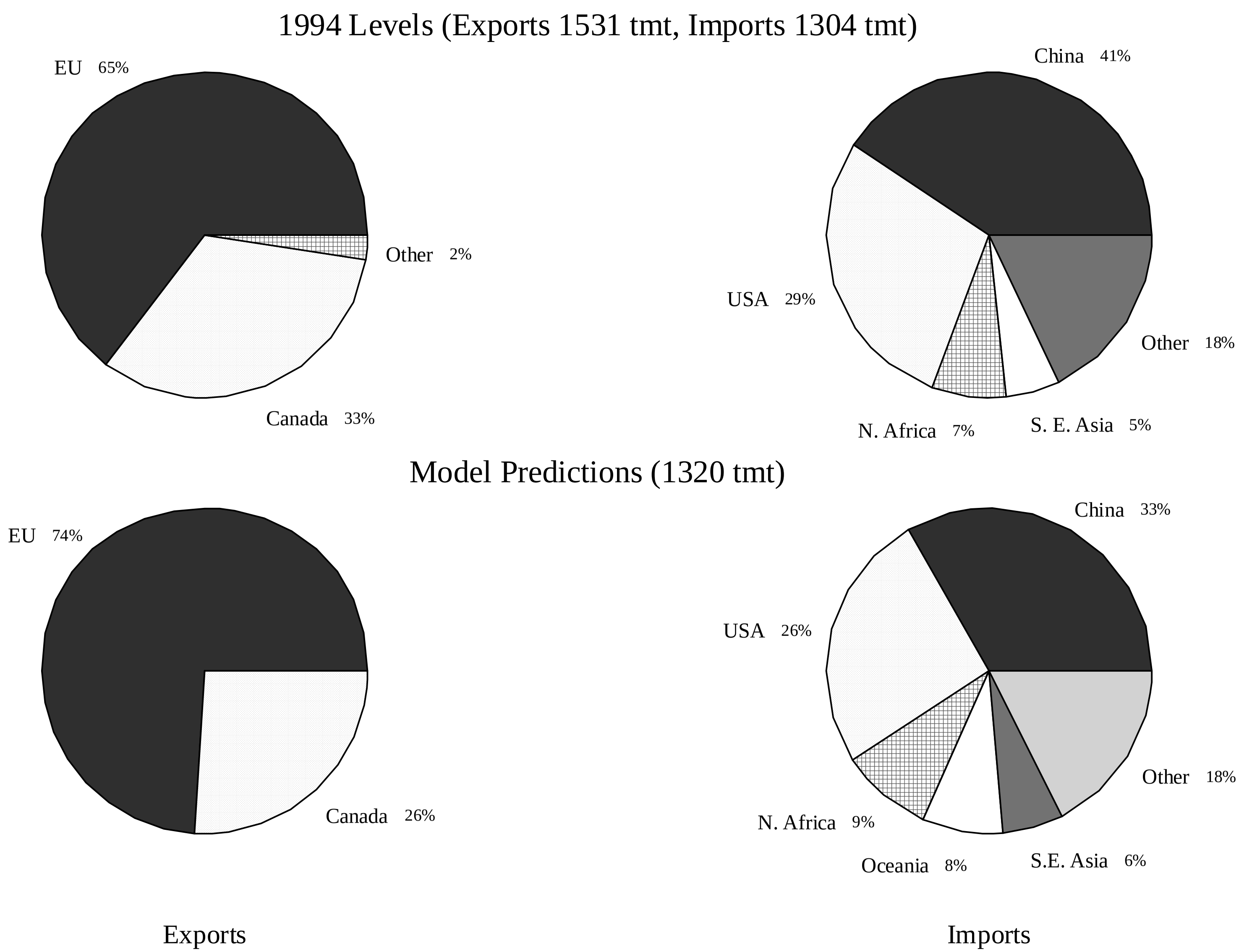

Figure 4.5. Shares of Major Canola Oil Trading Regions

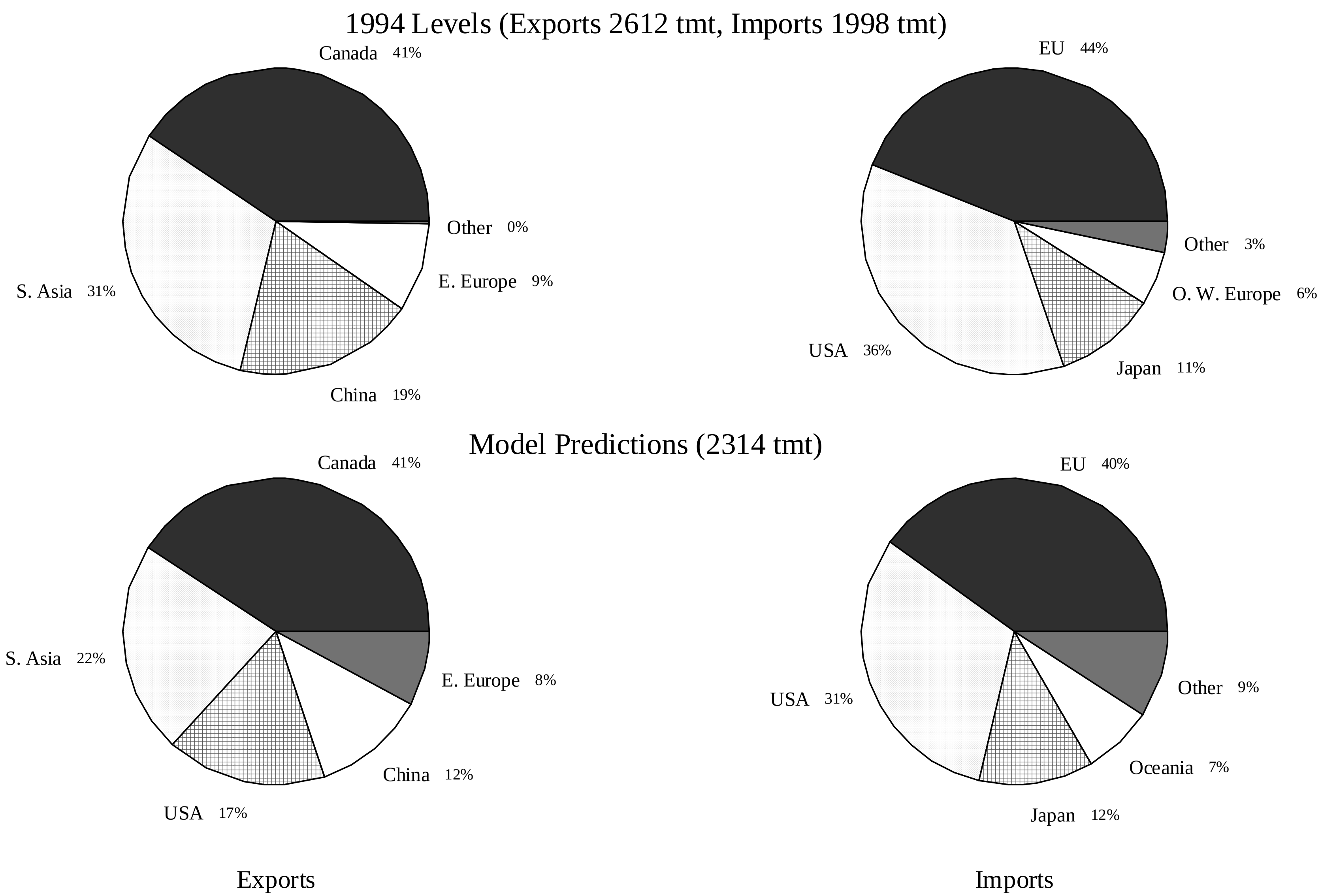

Figure 4.6. Shares of Major Canola Meal Trading Regions

The base case provides a standard for comparison. The following sections make frequent reference to Tables 4.8, 4.9, and 4.10, where base-case projections are shown alongside projections from alternative trade scenarios. Table 4.8 focuses on the U.S. sunflower and Canadian canola sectors, while Tables 4.9 and 4.10 summarize global impacts on production, trade, and prices of oilseeds and products.

Retention of U.S. SOAP Program

There were no subsidized sales of U.S. sunflower oil during the 1994 marketing year, so the SOAP program was not included in the base case. Budgetary pressures make it unlikely that SOAP will be funded under new U.S. farm programs. However, the effects of these subsidies on U.S. exports and producer prices are of interest. To gauge the hypothetical impact of SOAP, we applied the average bonus levels from FY 94 (beginning October 1993) to U.S. exports of sunflower oil in model simulations.[15] Results indicate that, with FY 94 bonus levels in targeted markets, U.S. sunflower oil exports rise to 707 TMT, 60 percent higher than in the base case (Table 4.8). U.S. sunflower seed exports fall to 304 TMT as a larger fraction of domestic production is crushed domestically. U.S. producer prices (sunflower seed) are 18 percent higher than in the base case. Thus, retention of SOAP would have a major impact on U.S. sunflower oil exports, domestic crushing, and producer revenue.

Globally, there is virtually no change in the weighted-average world price of sunflower seed (Table 4.9). However, the weighted-average world price of sunflower oil drops by $9/MT (1.5 percent) relative to the base case.

Although sunflower and canola products are substitutes in demand, the SOAP program has minimal impact on world canola prices (Table 4.9). Canada crushes more of its canola seed domestically (Table 4.8) as seed exports to the United States are reduced. That is due to expanded sunflower crushing in the United States, which reduces available capacity for U.S. crushing of Canadian canola seed.

[15]Average bonus levels ($/mt) in FY 94 varied by region, as follows: $133.1 (Mexico); $143.1 (Central America); $115.3 (Venezuela); $67.5 (Turkey); and $110.5 (North Africa).

Table 4.8. Comparison of Alternative Trade Scenarios*

	Base Case	U.S. Retains SOAP	U.S. Sunflower Supply		NAFTA			GATT	Free Trade	CHINA		Japan Tariff Elim	EU Supply (-10%)	Argen. Exp. Sub. Elim.
			Decr. 20%	Incr. 20%	As Is	+ Arg .& Chile	Western Hemis.			Tariff Elim.	+ Higher Oil Ylds			
US Sunflower														
Seed Price ($/mt)	227	267	230	224	228	232	233	228	245	229	220	227	229	229
Production (tmt)	2041	2236	1871	2211	2045	2063	2067	2043	2128	2050	2006	2042	2049	2049
Crush (tmt)	1361	1932	1326	1436	1465	1995	1913	1483	1960	1412	1277	1424	1365	1390
Prod. Rev. ($ mil)	464	596	431	496	466	478	481	465	521	469	442	464	469	469
Seed Exports (tmt)	680	304	545	776	580	68	155	560	168	638	730	617	684	659
% of World	32	15	27	35	28	5	11	27	5	31	33	30	32	31
Oil Exports (tmt)	442	707	429	472	486	728	676	493	719	462	403	469	444	455
% of World	24	34	23	25	26	31	23	26	24	25	21	25	24	25
Canadian Canola														
Seed Price ($/mt)	240	240	240	240	240	245	245	240	256	248	233	238	241	240
Production (tmt)	6411	6412	6418	6405	6421	6521	6523	6418	6781	6608	6256	6373	6453	6415
Crush (tmt)	2195	2425	2168	2207	2240	2511	2411	2226	2436	2179	2299	2325	2191	2199
Prod. Rev. ($ mil)	1536	1537	1540	1533	1541	1594	1595	1540	1736	1641	1456	1516	1558	1538
Seed Exports (tmt)	4262	4033	4296	4244	4226	4010	4153	4237	4392	4476	4002	4093	4308	4262
% of World	90	90	91	90	90	96	96	90	89	92	72	96	91	90
Oil Exports (tmt)	343	434	332	347	362	477	436	356	464	348	376	396	342	344
% of World	26	31	26	26	25	25	27	23	22	23	23	21	26	26

*All prices in U.S. dollars per metric ton.

Table 4.9. World Production, Trade, and Weighted Average Prices Under Alternative Scenarios*								
	Base Case	U.S. Retains SOAP	U.S. Sunflower Supply		EU Supply Redn.	NAFTA		
			Reduce Acres	Increase Acres		As is	+ Arg. & Chile	Western Hemis.
Sunflower Seed								
Production	19207	19301	19110	19304	19168	19228	19216	19243
Trade	2133	2022	2012	2213	2142	2034	1376	1436
Price	260	260	263	258	262	261	259	261
Sunflower Oil								
Production	7775	7815	7734	7816	7759	7784	7782	7793
Trade	1847	2065	1851	1859	1859	1896	2326	2990
Price	626	617	632	620	630	627	629	629
Sunflower Meal								
Production	9281	9326	9234	9328	9262	9291	9287	9299
Trade	2888	3005	2906	2890	2908	2940	4907	5025
Price	110	110	110	109	110	110	110	110
Canola Seed								
Production	26182	26180	26195	26170	26120	26198	26238	26242
Trade	4724	4496	4727	4711	4755	4691	4179	4337
Price	260	260	260	260	262	260	259	259
Canola Oil								
Production	9751	9751	9756	9746	9725	9758	9785	9786
Trade	1320	1402	1297	1325	1297	1429	1891	1645
Price	617	617	618	617	620	617	615	616
Canola Meal								
Production	15733	15733	15741	15726	15699	15743	15753	15756
Trade	2314	2321	2316	2311	2324	2459	2305	2220
Price	136	135	136	136	136	135	134	134

*Prices in U.S. dollars per metric ton; quantities in thousand metric tons.

Table 4.10. World Production, Trade, and Weighted Average Prices Under Alternative Scenarios*							
				China			
	Base Case	GATT	Free Trade	Tariff Elim.	+ Higher Oil Yields	Japan Tariff Elim.	Argen. Exp. Sub. Elim.
Sunflower Seed							
Production	19207	19206	19380	19251	19022	19209	19175
Trade	2133	2046	3126	2078	2186	2067	2119
Price	260	261	262	261	258	261	260
Sunflower Oil							
Production	7775	7775	7853	7795	7905	7776	7762
Trade	1847	1891	2935	1877	1953	1874	1828
Price	626	627	619	629	602	627	629
Sunflower Meal							
Production	9281	9281	9366	9302	9088	9282	9266
Trade	2888	2940	3153	2914	2782	2895	2879
Price	110	110	108	109	114	109	110
Canola Seed							
Production	26182	26193	26551	26437	25990	26195	26188
Trade	4724	4691	4927	4884	5521	4275	4723
Price	260	260	258	256	258	263	260
Canola Oil							
Production	9751	9756	9926	9863	10200	9752	9754
Trade	1320	1538	2136	1530	1628	1864	1321
Price	617	617	594	601	561	615	617
Canola Meal							
Production	15733	15740	15919	15874	15297	15746	15737
Trade	2314	2438	2099	2145	2224	2411	2314
Price	136	136	137	134	147	140	136

*Prices in U.S. dollars per metric ton; quantities in thousand metric tons.

Shifts in U.S. Sunflower Acreage

Historically, U.S. sunflower acreage has shifted in response to farm program changes. The effects of new commodity policies (e.g., complete decoupling of support payments) are difficult to anticipate. To provide some perspective on the effects of possible acreage shifts, two model simulations were done. These assume, respectively, a 20 percent reduction in U.S. sunflower acreage (at given prices) and a 20 percent expansion.[16]

The shifts in supply functions lead to proportionately smaller changes in U.S. production levels because of mitigating price effects (Table 4.8). Thus, when supply functions shift leftward by 20 percent, prices rise moderately (relative to the base case) and sunflower seed production falls by only 170 TMT, or 8.3 percent. Similarly, a rightward shift in supply leads to a small price decrease, so that production expands by only 8.3 percent. In both cases, the supply shifts lead to changes in U.S. export levels of sunflower seed and oil. As expected, U.S. exports decline because of acreage reductions and rise from acreage increases.

Impacts of NAFTA

Three different NAFTA scenarios were investigated. The first represents full implementation of the current agreement between the United States, Canada, and Mexico. This entails elimination of Mexico's import trade barriers (currently 10 percent for both oils). The second scenario involves accession of Argentina and Chile to the North American free trade area. These South American producers would eliminate import barriers and export subsidies for trade within the region. In the base case, tariffs and subsidies for southern S. America reflect a mixture of national policies: 2½ percent export tariffs apply for exports of sunflower oil and meal (Argentina), while 50% import tariffs apply for meal imports (Chile). The third scenario involves extension of the free trade area to the entire Western Hemisphere.

The first NAFTA scenario shows minimal impact on the U.S. sunflower sector (Table 4.8). Canada's oil exports increase while canola seed exports decrease, due to elimination of effective protection for Mexico's crushing industry. However, there is no significant change in Canadian producer revenue. In the second scenario, U.S. and Canadian producers benefit from the elimination of Argentina's export subsidies and Chile's import tariffs. U.S. and Canadian oil exports rise sharply, and producer revenues increase relative to the base case. Domestic crushing of U.S. sunflowers increases by 47 percent relative to the base case. The third scenario (extension of free trade to the Western Hemisphere) provides a modest benefit to U.S. sunflower producers, but leaves canola basically unchanged.

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[16]These represent horizontal shifts of the U.S. seed supply functions. Technically, we multiply the intercepts by 0.8 or 1.2. (See equation 4.)

Impacts of the first NAFTA scenario on global production, trade, and prices are insignificant (Table 4.9). For canola, the admission of Argentina and Chile has more pronounced effects on global trade: trade in canola seed is reduced, while trade expands in canola products (oil and meal). In the second and third NAFTA scenarios, world weighted-average prices fall for canola seed and products.

GATT and Free-Trade Scenarios

As a result of the Uruguay Round, import barriers to minor oilseeds and products will be reduced in many regions of the world. However, the negotiated reductions will leave significant trade barriers in individual markets, including countries such as China that are not now signatories of the GATT. For comparison, we performed a GATT simulation, assuming full implementation of the Uruguay Round reforms, and a "free trade" simulation. The latter assumes complete elimination of current trade taxes and subsidies throughout the world.

Model simulations suggest that the Uruguay Round reforms will have no significant effects on minor oilseed producers in North America (Table 4.8). However, the free-trade scenario yields major impacts: producer revenue rises by 12 percent (relative to the base case) for U.S. sunflowers, and by 13 percent for Canadian canola. Under free trade, both the United States and Canada sharply increase their oil exports. Because of increased global trade volumes, the shares of U.S. and Canadian oil exports are little changed relative to the base case.

On the global level, results of the GATT scenario are barely distinguishable from the base case (Table 4.10). Global seed production and prices are virtually unchanged. Exports of canola oil increase by 16 percent relative to the base case, but other trade levels are similar. By contrast, global free trade leads to expanded production and trade for both oilseeds and their products. Seed prices rise, while oil prices fall, due to the elimination of discriminatory tariff structures.

China Trade Scenarios

China is (at least potentially) a major force in the market for both minor oilseeds. China produced about 25 percent of the world's rapeseed in 1994, and 6 percent of the world's sunflower seed. In recent years, China has imported significant quantities of rape oil, about 29 percent of domestic consumption in 1994. China has high import tariffs for rapeseed (64 percent) and rape oil (25 percent). China also maintains a 45 percent import tariff for sunflower oil. The tariff on meal imports (both types) is 68 percent.

To assess the importance of China for world trade in minor oilseeds, two simulations were conducted. In the first scenario, import tariffs on oilseed products are removed, but we retain other base-case assumptions, in particular, low oil yields for Chinese rapeseed and sunflower production. In the second scenario, in addition to eliminating Chinese tariffs, we assume the adoption of improved oilseed varieties, with oil yields (extraction rates) equal to North American levels.[17]

As expected, results in Table 4.8 indicate that elimination of Chinese tariffs would benefit North American producers. The impact is relatively small for sunflowers, but fairly substantial for canola (7 percent higher producer revenue relative to the base case).

On the other hand, the effects of higher Chinese oil yields (combined with tariff elimination) are negative for North American producers due to higher world oil production and depressed prices. Producer revenue declines about 5 percent in the United States and Canada, relative to the base case. Both countries lose oil market share, although the United States increases its exports of sunflower seeds.

Japan Tariff Elimination

Japan accounts for a large share of world imports of canola seed, in part because of tariff differentials. In the base case, Japan applies a 36 percent import tariff on canola oil, and a 3 percent tariff on canola seed. No tariffs are applied on meal imports. These tariffs imply substantial effective protection for Japanese crushers.

To assess the impact of this tariff structure, a simulation was conducted in which Japanese tariffs were removed altogether. The results contrast sharply with the base case. With tariffs in place (the base case), Japan imports 1,969 TMT of canola seed, zero canola oil, and 279 TMT of canola meal. With tariffs removed, Japan's seed imports are reduced to 453 TMT, while oil imports rise to 644 TMT and meal imports rise to 1,052 TMT.

These changes do not appear to benefit Canadian producers. As shown in Table 4.8, Canadian prices and producer revenue decline as a result of Japan's tariff elimination. That is likely due to changes in trade patterns. In the base case, Canada supplies 84 percent of Japan's canola seed imports. With tariff elimination, Japan's seed imports fall by three-quarters, and Japan's oil imports are supplied almost exclusively by the EU (99 percent). Thus, Canada appears to enjoy a comparative advantage in shipping seed to Japan and is favored by the current tariff structure to some extent.

EU Supply Reduction

The European oilseed sector is adjusting to ongoing reforms of the Common Agricultural Policy (CAP). Oilseed prices in Europe are now close to world market levels, and the new CAP regime (introduced in 1992) places restrictions on acreage and yields. Impacts on supply are

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[17] In the base case, Chinese oil yields are 33 percent for rapeseed and 22 percent for sunflower. These compare to North American oil yields of 41 percent (canola) and 42 percent (sunflower).

difficult to predict due to changes in other price supports (e.g., cereals), uncertainty about the effectiveness of set-asides, and scope for further productivity gains (OECD). However, reductions in EU oilseed supplies seem plausible.

To simulate the impact of lower European production, we shift the EU supply schedules for rapeseed and sunflower (leftward) by 10 percent. Results in Table 4.8 show the expected, positive effects on North American producer revenue. However, U.S. exports of sunflower seed and oil are virtually unchanged. Globally, prices increase for both seeds and oils (Table 4.9).

Argentine Export Subsidies

Argentina and Chile were combined for regional aggregation. (They are identified as southern South America in Tables 4.1 through 4.7). However, as Chile is not an exporter, we used Argentina's export taxes and subsidies in base-case simulations. Argentina applies a 3.5 percent *ad valorem* duty on sunflower seed exports, while subsidizing exports of sunflower oil and meal at a rate of 2.5 percent. This encourages domestic processing of Argentine sunflowers before export.

To evaluate the significance of this structure, we conducted a simulation in which Argentine export taxes and subsidies were eliminated. At a global level, the most notable effect is a rise in the world price of sunflower oil, relative to the base case, about $3/MT (Table 4.10).

5. SUMMARY AND DISCUSSION

This paper has presented simulation results from a spatial-equilibrium model of world trade in sunflower and canola (rapeseed), and their respective products. Parameterized with 1994 supply and demand data, the model was used to assess several trade policy scenarios.

The base-case simulation reflects 1994 levels of production and demand, tariffs and subsidies (which vary substantially by region), and estimated shipping costs. Within North America, sunflower production and crushing are primarily in the United States, while Canada accounts for nearly all of the canola production. U.S. consumption of canola oil (imported from Canada) is substantially larger than U.S. consumption of sunflower oil. In addition, the model projects large U.S. imports of canola meal; this includes some transshipment of canola meal through U.S. ports. About two-thirds of Canada's canola production is exported as seed. This largely reflects Japan's protection of its domestic crushing industry (i.e., high oil tariffs). By contrast, about one-third of the U.S. sunflower production is exported as seed. The low density of sunflower seeds raises their shipping cost relative to oil and meal.

The SOAP program was shown to have a major impact on U.S. sunflower oil export volume, domestic crushing, and producer prices. The end of this program will represent an important challenge to the U.S. sunflower sector. Other simulations showed the impact of acreage shifts, which may ensue from recent changes in farm programs, on the U.S. sunflower sector. Shifts in sunflower acres are reflected in producer prices and in capacity utilization of U.S. crushing plants.

Elimination of Mexico's import tariffs will have little impact on the U.S. sunflower or Canadian canola. However, the extension of NAFTA to other countries could lead to major benefits. If Argentina and Chile accede to the free trade area (and Argentina eliminates its existing export subsidies for sunflower oil), gains to U.S. and Canadian producer revenue would be 3-4 percent. There would be small further gains if the free trade area were extended to other Western Hemisphere countries.

The GATT agreement will have minimal impact on North American producers, according to our analysis. The free-trade scenario, however, shows dramatic increases in oil export volume from the United States (sunflower) and Canada (canola) and sharply higher prices and producer revenue. This underscores the fact that the GATT agreement leaves major trade barriers in place for minor oilseeds and, especially, oil and meal.

China is emerging as a major force in the world market. While elimination of Chinese tariffs on oil and meal would benefit North American producers of minor oilseeds, production shifts in China (toward high oil-yielding varieties) could have the opposite effect. Another major Asian market is Japan, whose tariff structure now encourages imports of seeds instead of oilseed products. Results of model simulations suggest that North American producers would not necessarily gain from the elimination of Japanese tariffs. To the contrary, model projections show a slight decline in Canadian producer revenue under this scenario, possibly because Canada now enjoys a competitive advantage in shipping canola seed to Japan.

Limitations of the Analysis

The model is formulated in a static, partial equilibrium framework. Thus, it cannot be used to address issues of dynamic adjustment (i.e., to policy changes or other exogenous shocks) or price interactions between minor oilseeds and other commodities. The latter point is more serious, because, in reality, market conditions for sunflower and canola are bound to reflect conditions for other oilseeds, particularly soybeans, whose production and trade patterns will also be affected by policy reforms.

Within each oilseed category (sunflower or canola), seed and products are assumed to be homogeneous. Exceptions were made for China, the FSU, and South Asia, where extraction rates are significantly below world averages. Although a standard feature of spatial equilibrium models, this ignores actual variation in product qualities across world regions. Qualities of rapeseed/canola products, in particular, reflect differences in varieties grown and processing technology. The result is that oil or meal from different regions may not be perfectly substitutable, contrary to assumptions of the model.

Regional definitions and the choice of base-year (for estimating model parameters) are important determinants of the results. Inevitably, some level of detail is sacrificed whenever countries are grouped together for purposes of analysis. Our treatment of the EU and the FSU as single regions is open to question, given their geography and internal logistics. However, more detailed spatial disaggregation of these world regions did not seem necessary, given our primary interest in the effects of trade on North America. It was natural to include much greater detail about the location of production and crushing in the United States and Canada. The use of single basing points for oil and meal demand in the United States and Canada, while simplistic, reflects the absence of data on regional (sub-national) demand.

Other data inadequacies should be recognized. Lacking data on internal prices for oilseeds and products in various world regions, we estimated supply and demand parameters with available world prices. Crushing margins, an exogenous model parameter, were fixed in consultation with industry experts. To the extent that these may deviate from actual margins (because of competitive conditions in specific regions), the model will fail to replicate actual price relationships between oilseeds and products.

These problems notwithstanding, the model provides a comprehensive basis for studying the impact on domestic oilseed producers and processors of specific changes in world markets or competitor policies. Simulation results can help to provide perspective for industry and government officials as they consider the implications of global trade liberalization and other policy reforms.

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APPENDIX 1: DERIVATION OF DEMAND PARAMETERS

Demand parameters for oil and meal are derived to be consistent with regional elasticities, prices, and market shares. The parameters are derived from formulas developed by Armington. However, in our model, product demands are differentiated by type (sunflower or rapeseed), rather than by country of origin.

For each oil-consuming region *r*, let η^r denote the overall price elasticity of demand and σ^r the elasticity of substitution between two oil types. Let s^r_k denote the average market share of type-k oil in the base period. The direct price elasticity of demand for type-k oil is given by

$$\eta^r_{kk} = -(1 - s^r_k)\sigma^r + s^r_k \eta^r$$

and the cross-price elasticity (with respect to type-$\tilde{k}$ price) is given by:

$$\eta^r_{k\tilde{k}} = s^r_k(\sigma^r + \eta^r)$$

The relative magnitudes of σ^r (positive) and η^r (negative) determine the sign of the cross-price elasticity. The elasticity of substitution must be larger than the overall demand elasticity (in absolute value) for the two oils to be substitutes in demand.

Using these elasticities, oil demand parameters are derived as follows:

$$b_{rk} = \eta^r_{kk} \frac{Q\bar{O}D_{rk}}{P\bar{O}_{rk}}$$

$$c_{rk} = \eta^r_{k\tilde{k}} \frac{Q\bar{O}D_{rk}}{P\bar{O}_{r\tilde{k}}}$$

$$a_{rk} = Q\bar{O}D_{rk} - b_{rk}P\bar{O}_{rk} - c_{rk}P\bar{O}_{r\tilde{k}}$$

with quantities and prices set at their base levels. Meal demand parameters are derived in a similar manner using appropriate elasticities, prices, and quantities.

In base-case simulations, the elasticity of substitution between sunflower and rapeseed is set equal to twice the overall demand elasticity in absolute value (i.e., $\sigma^r = 2|\eta^r|$) for both oil and meal in each consuming region.[18] This ensures that sunflower and rapeseed products are substitutes in demand. For comparison, we also conducted simulations with different demand parameters. In the first case, the elasticity of substitution (for meal and oil) is set equal to the overall elasticity in absolute value ($\sigma^r = |\eta^r|$). This implies zero cross-price effects in the demand for sunflower or rapeseed products. In the second case, the elasticity of substitution is set equal to four times the overall elasticity ($\sigma^r = 4|\eta^r|$), accentuating the cross-price effects. These alternative assumptions do not lead to major changes in model results. Table A1.1 displays average world prices for sunflower and rapeseed projected by the model under alternative elasticity assumptions.

Table A1.1: Impact of Alternative Elasticities of Substitution on Projected Prices

	Base Case $\sigma^r = 2\|\eta^r\|$		$\sigma^r = \|\eta^r\|$		$\sigma^r = 4\|\eta^r\|$	
	--$/MT--					
Price	Sunf	Rape	Sunf	Rape	Sunf	Rape
Seed	260.5	260.2	262.8	258.7	257.6	261.8
Oil	626.4	617.2	633.4	612.3	619.5	621.7
Meal	109.8	135.7	108.4	136.6	110.4	134.9

†Average world prices, weighted by crush (seed) or consumption (oil and meal), projected by the model.

In general, with higher elasticities of substitution, the average price spread between sunflower and rapeseed is reduced. However, the effects shown in Table A1.1 are not very pronounced. While our base-case assumption about σ^r is fairly *ad hoc*, it does not seem particularly critical.

Tables A1.2 and A1.3 list the elasticities and 1994 quantities (by region) used to generate demand parameters for the base case. Also listed are 1994 quantities produced, quantities crushed (for specification of capacity constraints outside North America), and trade taxes and subsidies by region.

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[18]The symbols η^r and σ^r were introduced for oil demand. Similar parameters apply for meal demand in each region. These are not specified in the text. However, in the following discussion, it should be understood that, in the case of meal, the elasticity of substitution (between sunflower and rapeseed) is also assumed to be a multiple of the overall demand elasticity.

Table A1.2. Data for Generating Base Case, Sunflower Seed and Products

	Sunflower Seed					Sunflower Oil					Sunflower Meal				
	Elast. of Supply	Production	Crush	Import Tariff	Export Tariff/Sub	Elast. of. Demand	Production	Consump-tion	Import Tariff	Export Tariff/Sub	Elast. of Demand	Production	Consump-tion	Import Tariff	Export Tariff/Sub
USA	0.55	2194	1250	0	0	-0.69	500	130	0	0	-0.9	617	554	0	0
Canada	0.85	117	50	0	0	-0.6	22	31	0	0	-1	17	17	0	0
Mexico	0.5	2	87	0	0	-0.9	30	229	0.1	0	-1.1	38	47	0	0
Cen. America	0	0	0	0	0	-1	0	22	0.0374	0	0	0	0	0	0
Caribbean	0	0	0	0.005	0	-1	0	40	0.0845	0	-0.9	0	40	0	0
Venezuela	0	15	15	0	0	-0.75	7	152	0.2	0	-1.5	7	7	0.15	0
E. S. America	0	65	60	0.1225	0	-1.1	20	25	0.158	0	-0.9	24	16	0	0
S. S. America	0.7	5020	4170	0.3621	0.035	-1	1710	375	0.0966	-0.025	-1.3	1754	91	0.5	-0.03
W. S. America	0	3	3	0.078	0	-1.1	1	5	0.0697	0	0	1	1	0	0
East Europe	0.25	2416	1822	0.0808	0.0514	-0.7	750	725	0.1388	0.006	-0.3	859	919	0	0
O. W. Europe	0.3	90	66	0	0	-0.5	28	66	0	0	-0.55	31	28	0	0
Turkey	0.15	650	1160	0	0	-0.13	487	505	0.1411	0	-0.5	441	391	0	0
Egypt	0.2	50	36	0.01	0	-0.2	13	263	0.021	0	-0.35	16	46	0	0
Middle East	0.15	49	23	0	0	-0.13	10	317	0.004	0	-0.5	10	210	0	0
North Africa	0.15	48	40	0.2	0	-0.13	14	239	0.1016	0	-0.35	17	42	0.44	0
West Africa	0	0	0	0	0	-0.2	0	3	0	0	0	0	0	0.2	0
East Africa	0	69	44	0	0	-0.2	16	16	0	0	-0.25	20	20	0	0
South Africa	0.35	525	517	0.0767	0	-0.65	217	404	0.2285	0	-0.57	253	252	2.6608	0
China	0.1	1500	1061	0	0	-0.5	233	233	0.45	0	-0.32	615	535	0.68	0
Japan	0.9	0	0	0.03	0	-0.35	0	13	0.321	0	0	0	0	0	0
S. E. Asia	0	110	99	0	0	-1	38	38	0	0	-0.5	45	45	0	0
South Asia	0.4	1606	1497	0.22	0	-0.5	530	560	0.4809	0	-0.18	667	517	0.61	0
Oceania	0.6	111	91	0	0	-0.65	38	51	0	0	-0.44	49	49	0	0
FSU	0.15	4443	2552	0.01	0	-0.15	1067	1480	0.1	0	-0.25	976	1051	0	0
EU	0.75	3969	5141	0	0	-0.56	2108	1877	0.1	0	-0.7	2822	4249	0	0

Table A1.3. Data for Generating Base Case, Canola Seed and Products

	Canola Seed					Canola Oil					Canola Meal				
	Elast. of Supply	Production	Crush	Import Tariff	Export Tariff/Sub	Elast. of. Demand	Production	Consump-tion	Import Tariff	Export Tariff/Sub	Elast. of Demand	Production	Consump-tion	Import Tariff	Export Tariff/Sub
USA	0.55	209	455	0	0	-0.69	153	529	0	0	-0.9	242	967	0	0
Canada	0.85	7228	2450	0	0	-0.6	980	240	0	0	-1	1430	375	0	0
Mexico	0.5	0	475	0	0	-0.9	190	240	0.1	0	-1.1	263	263	0	0
Cen. America	0.45	0	0	0	0	-1	0	1	0.0217	0	0	0	0	0	0
Caribbean	0.45	0	0	0	0	-1	0	15	0.1	0	0	0	0	0	0
Venezuela	0.42	0	0	0	0	0	0	0	0.2	0	0	0	0	0.15	0
E. S. America	0.45	1	0	0	0	0	0	0	0.089	0	0	0	0	0	0
S. S. America	0.6	27	27	0.3735	0.035	-1	22	22	0.1486	0	-1.8	27	27	0.5	0
W. S. America	0.6	1	1	0	0	0	0	0	0.15	0	0	1	1	0	0
East Europe	0.25	1360	1194	0.0877	0	-0.15	484	438	0.386	0	-0.3	709	449	0.0582	0
O. W. Europe	0.3	719	578	0	0	-0.5	235	239	0	0	-0.55	344	459	0	0
Turkey	0.15	2	1	0.25	0	-0.13	0	5	0.1588	0	0	1	1	0	0
Egypt	0.2	0	0	0.05	0	0	0	1	0.021	0	0	0	0	0	0
Middle East	0.15	2	1	0	0	0	0	0	0.0781	0	0	0	0	0	0
North Africa	0.15	2	42	0.2	0	-0.13	15	120	0.1651	0	-0.35	25	25	0	0
West Africa	0.16	0	0	0	0	-0.2	1	54	0.017	0	0	0	0	0.2	0
East Africa	0.16	19	17	0	0	-0.2	6	19	0	0	-0.25	10	3	0	0
South Africa	0.35	0	0	0.1	0	-0.65	0	17	0.0834	0	0	0	0	0	0
China	0.1	7492	6842	0.6385	0	-0.5	2261	2791	0.25	0	-0.32	4242	3742	0.68	0
Japan	0.9	1	1910	0.03	0	-0.35	801	801	0.3574	0	-0.75	1100	1330	0	0
S. E. Asia	0	0	0	0	0	-0.9	0	70	0	0	-2	0	65	0	0
South Asia	0.4	5955	5497	0.495	0	-0.5	1823	1875	0.4568	0	-0.19	3656	2856	0.325	0
Oceania	0.6	309	299	0	0	-0.65	99	99	0	0	-0.44	170	170	0	0
FSU	0.15	292	199	0	0	-0.15	49	100	0.1	0	-0.25	117	117	0	0
EU	0.75	6594	6767	0	0	-0.56	2724	1700	0.1	0	-0.69	3972	4871	0	0

APPENDIX 2: SHIPPING COSTS

Costs of shipping seed and products (oil and meal) within North America are discussed first. Then, the derivation of ocean freight rates is summarized.

Costs of Shipping Seed

Shipping costs were gathered for canola and sunflower seeds from production regions to domestic crushing facilities and export positions. Separate costs were gathered for both rail and truck shipment of seeds. Rail shipment costs were first obtained from 1995 BN tariffs and CN rates from production regions to domestic crushing facilities and export positions. Where specific tariffs were not quoted, the rate mileage tariff was used to estimate rail shipment costs. Rail rates for sunflower to Mexico were gathered to Eagle Pass, TX.

Separate costs were also estimated for truck shipment of seeds based on two mileage formulas: one for shipment with Canadian origins, and one for U.S. origins. Shipments within Canada assumed a double trailer or a 43-ton load per truck. Transhipments from Canada to the United States assumed a single trailer or 23-ton loads. Shipments within the United States assumed 50,000 lbs. per truckload. The highway mileage matrix was generated from data obtained with *AUTOMAP*. All rates included a charge for handling at the local elevator and terminal handling at export positions. Handling charges for Canadian origins were assumed at $CA 11/MT at local elevators and $CA 7.98/MT at terminal elevators. U.S. handling charges were $US .08/bu at both local and terminal elevators.

Canadian Truck Cost:

Cost = $CA 2.7 per loaded mile for 43 ton loads within Canada.
Cost = $CA 3.0 per loaded mile for 23 ton loads (Transhipment to United States).
Source: Kris Olson - Alberta Wheat Pool, Calgary.

U.S. Truck Cost:

Cost = $US 1.05 per loaded mile.
Source: Guy Christensen - ADM (National Sun Industries).

Shipping Costs for Oil

Shipping costs were estimated for oil from crushing plants to export positions and local consumption points in Canada and the United States. Shipping rates were gathered for Burlington Northern (BN) tariffs for shipment of oils where available. Remaining rates were estimated based on the rate distance tariff for shipment of oils. Mileage from station to station was taken from BN distance tariff and 1995 Canadian Pacific (CP) station-to-station mileage estimates. U.S. domestic consumption used a basing point of Minneapolis. All North American shipping costs to the U.S. domestic market were calculated from crushing plants to Minneapolis. Canadian consumption of sunflower and canola oil assumed a basing point of Toronto. Similarly, North American shipping costs to the Canadian domestic market represent the cost of shipping from crushing plants to Toronto.

Shipping Costs for Meal

Shipping costs for sunflower and canola meal were gathered from crushing plants to domestic markets and export positions. Rail rates were gathered from BN sunflower and canola meal tariffs where available. When rates were not available, the BN distance rate tariff for sunflower and canola meal was used. Basing points for the Canadian sunflower and canola meal markets and the U.S. meal market were assumed. Canadian canola meal used a basing point of Calgary. Canadian sunflower meal market used Winnipeg as the basing point. For the U.S. meal market, the basing point was Minneapolis.

Ocean Freight Costs

An important aspect of the empirical model is ocean freight costs. Results of a model using ocean freight rates would be highly sensitive to the selection of the season and corridor (Caron). Therefore, instead of rates, our model uses ocean freight costs. Viscencio-Brambila and Fuller also used ocean freight costs from U.S. Army Corps of Engineers (ACE) data when estimating the effect of deepening U.S. Gulf ports to accommodate larger-sized ocean vessels. Cost data for deep draft ocean vessels are published by the U.S. Army Corps of Engineers. Cost estimates for bulk movements of sunflower and canola seed and tanker movements of sunflower and canola oil are estimated with a 1-2-3 spreadsheet. The method was to select ports and obtain estimates of distances between them, determine vessel and shipment sizes by trade corridor, and calculate costs.

Selection of Ports. The world was subdivided into 25 demand regions. Within each demand region, numerous ports may actually import oil. For model simplification, one port was selected for each region (Table A2.1). The port selection criteria included proximity to other shipping points and availability of distance data.

Sunflower/canola oil is shipped in tankers. Countries/regions were allocated oil demands on the basis of observed trade levels and discussions with industry officials. The data were used to provide a baseline for actual trade levels and to help determine vessel size. One important exception is Japan, which receives raw sunflower or canola seed.

Eight ports for the five principal exporting regions were identified in discussions with industry officials and a review of port literature. Export points are Sydney, Australia; Buenos Aires, Argentina; Hamburg, Germany; Thunder Bay and Vancouver, Canada; and Duluth, Minnesota, Portland, Oregon, and New Orleans.

Table A2.1. Importing Regions and Countries, Ports, and Average Level of 1991-1993 Imports

Region/ Country	Principal Importing Countries in Region	Port(s) of Entry
United States		Mobile, Portland, OR; Duluth, MN
Canada		Vancouver, Thunder Bay
Mexico		Tampico
Central America	Belize, Costa Rica, Guatemala, Honduras, Nicaragua, and Panama	Balboa, Panama
Caribbean	Cuba, Dominican Republic, Jamaica, and Haiti	Kingston, Jamaica
Venezuela		Puerto la Cruz
Eastern South America	Bolivia, Brazil, Paraguay, Uruguay	Recife, Brazil
Southern South America	Argentina, Chile	Buenos Aires, Argentina
Western South America	Colombia, Ecuador, Peru	Callao, Peru
EC-12		Hamburg, Germany
Non EU Western Europe	Sweden	Stockholm, Sweden
Eastern Europe	Austria, Czech Republic, Poland, Yugoslavia	Gdynia, Poland
Former Soviet Union		Odessa, Russia
North Africa	Algeria, Morocco, Tunisia	Algiers, Algeria
Egypt		Suez
East Africa	Libya, Ethiopia, Kenya, Mozambique, Somalia, Sudan	Mombasa, Kenya
South Africa	Angola, Congo, Madagascar, South Africa, Zambia, Zimbabwe	Capetown, South Africa
West Africa	Guinea, Ivory Coast, Liberia, Mauritania, Nigeria, Senegal	Lagos, Nigeria
China	China, Hong Kong	Shanghai
Japan		Tokyo
Southeast Asia	Indonesia, Malaysia, Philippines, Singapore, Thailand	Jakarta
South Asia	Bangladesh, India, Pakistan	Bombay, India
Middle East	Iran, Iraq, Israel, Jordan, Syria	Bahrain
Turkey		Istanbul
Oceania	Australia, New Zealand	Sydney, Australia

Calculation of Costs. Point-to-point cost estimates require information about three factors: distance, payload, and unit costs. Seed and oil ocean costs are expressed in dollars per metric ton.

First, distances in nautical miles between points of export and import were found in *Ports of the World* and *Lloyd's Maritime Atlas.* Second, sunflower seed and canola are light commodities. Thus, there is a concern that the shipment will "cube out," or use the full volume of a vessel before weight limits are met. Sunflower seed weighs 28 lbs. per bushel, which means a metric ton of sunflower seed is 78.7 bushels. Canola weighs 50 lbs. per bushel, meaning a metric ton of canola seed is 44.2 bushels.

Finally, unit costs are taken from ACE cost estimates for deep-draft vessels.[19] ACE estimates are published for U.S. and foreign flag tankers, dry bulk, container, and general cargo deep-draft vessels. Our work uses ACE data for foreign flag dry bulk and tankers.

The ACE data includes assumptions about vessel size and speed (Table A2.2). For example, deadweight tons and cubic capacity of ships are reported for bulk vessels.

Based on a cubic capacity per bushel of 1.24, the bushels per ship were determined as:

$$Bushels/ship = \frac{Ship\ \ cubic\ \ capacity}{1.24\ \ cubic\ feet/bushel}$$

For sunflower seed, the shipment size is the bushels per ship divided by 78.7 bushels per mt. The equations for bulk canola, meal, and pellets are identical, with bushels per ship divided by 44.2, 45.8, and 38.6, respectively. Sunflower and canola seed, meal, and pellets never reach the weight capacity, regardless of vessel size.

The ACE data on average total cost are reported on a per-hour basis (Table A2.3). Annual capital cost is based on a 20-year useful life and an interest rate of 8.25 percent. Fixed annual operating costs include wages and benefits, stores and supplies, maintenance and repair, insurance, other, and administration.

[19]The Army Corps of Engineers data are taken from the *FY 1993 Planning Guidance.* This report is available from George Antle, Dept. of the Army, Water Resources Support Center, 7701 Telegraph Rd., Casey Bldg., Alexandria, VA 22310-3868.

Table A2.2. Assumed Characteristics of Bulk Cargo and Container Ships

Ship Characteristics	Dry Bulk	Tanker
Deadweight tons	15,000	20000
Capacity	690,000 cubic feet	n/a
Length	478 feet	519 feet
Beam	67 feet	76 feet
Draft	27.6 feet	29.5 feet
Speed	14 knots per hour	14 Knots per hour
Payload sunflower seed	7,074 mt	n/a
Payload canola seed	12,578 mt	n/a
Payload meal	12,144 mt	n/a
Payload pellets	14,421 mt	n/a

Source: Department of the Army, *FY 1993 Planning Guidance.*
n/a not applicable.

The annual fixed operating cost and capital cost are summed to obtain total annual fixed costs. Total daily fixed cost is obtained by dividing the annual fixed costs by 350 days. Daily fuel costs are reported at sea and in port. Since we are concerned with point-to-point movements, we only consider at sea fuel costs. Daily at sea fuel costs are added to total daily fixed costs to obtain total daily costs. These costs are then divided by 24 hours per day to arrive at an hourly total cost. Given the ACE cost per hour (Table A2.3), payload assumptions (Table A2.2), vessel speed (Table A2.2) and the distance matrix, point-to-point costs are calculated.

Table A2.3. Summary of Army Corps of Engineers Ocean Freight Cost Data		
Cost Item	Bulk Carrier	Tanker
Annual Capital Cost	1,885,359	7,385,546
Wages, Benefits, Subsistence	569,765	3,058,665
Stores and Supplies	143,206	408,753
Maintenance and Repair	330,857	1,833,004
Insurance	122,232	311,089
Other	152,674	302,538
Administration	131,873	591,405
Fixed Annual Operating Cost	1,450,607	6,505,454
Total Annual Fixed Costs	3,335,966	13,891,000
Total Daily Fixed Costs	9,531	39,689
Daily Fuel Costs (at sea)	2,567	2,751
Total Daily Costs (at sea)	12,098	42,440
Hourly Total Costs (at sea)	504	1,768

Source: Department of the Army, *FY 1993 Planning Guidance.*