2000

Agricultural and trade policy reform in Mexico: PROCAMPO, NAFTA, and pre-GATT

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Agricultural and trade policy reform in Mexico:

PROCAMPO, NAFTA, and pre-GATT

by

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A dissertation submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Major: Agricultural Economics

Major Professor: William H. Meyers

Iowa State University

Ames, Iowa

2000

UMI Number: 9962819

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Graduate College
Iowa State University

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CHAPTER 1. INTRODUCTION AND PROBLEM STATEMENT

Economic policies in Mexico have undergone tremendous change during the past decade. Some of these changes—especially those relating to reforms in agricultural and trade policies—have important implications for Mexico's domestic agricultural economy and international trade with the United States. Mexico's liberalization of agricultural and economic policies has been consistent with that of other developing countries as the number of outward-oriented policies has increased. This trend is largely due to an increasing awareness of the drawbacks associated with inward-oriented policies, such as continued government support for industries that are unable to compete internationally, losses incurred by consumers from purchasing higher-priced domestic goods, and large government expenditures.

The Mexican government began liberalizing domestic economic policy in the early 1980s and continued the process through the 1990s. Beginning in 1983, tariffs and nontariff barriers were gradually reduced. To ensure acceptance into the General Agreement on Tariffs and Trade (GATT), Mexico began to phase out nontariff barriers in 1985. In August 1986, Mexico joined the GATT and the pace of economic liberalization increased. For example, quotas were reduced and replaced by tariffs, which were then further reduced. In 1987, the United States and Mexico negotiated an agreement called "A Framework of Principles and Procedures for Consultations Regarding Trade and Investment Relations." Under the agreement, five different working groups were created to review policy problems. In the late 1980s, the Mexican government established an economic reform plan for 1989-94 called the Pact for Economic Stabilization and Growth (PECE). A main objective of PECE was to reduce government intervention in the private economy (Valdes 1993).

Many of the changes in government policies directly affected agriculture, including the Economic Solidarity Pact (ESP), which was negotiated in 1987 between the Mexican government and the domestic labor and business sectors. ESP objectives were to maintain price stability and economic growth. The program accelerated trade liberalization and reduced government agricultural production subsidies. Then, in 1989, the Mexican government further liberalized the agricultural sector by eliminating guaranteed prices for most commodities (exceptions were corn and dry beans, the main food staples) and replacing them with agreement prices. Indirect subsidies were also reduced for many crops (Valdes 1993). In 1992, a new land reform program gave communal farmers legal title to land to encourage investments.

The Mexican government also renewed its emphasis on trade activity and began negotiating bilateral and multilateral trade agreements, mainly within the Latin American region. In 1991, Chile and Mexico signed a free trade agreement, and Mexico continued negotiating trade initiatives with Colombia, Venezuela, and Central American countries. In December 1992, the North American Free Trade Agreement (NAFTA) among the United States, Canada, and Mexico was signed but had not yet been ratified. NAFTA was subsequently ratified by the U.S. Congress in December 1993, effectively continuing the process of liberalizing Mexico's economy. These free trade negotiations were somewhat unique, given that this was the first time that a Mexican president explicitly linked rural development and domestic food policy to trade policy (Valdes 1993).

On October 9, 1993, Mexican President Carlos Salinas de Gortari introduced a new policy program, PROCAMPO, for the Mexican farm sector. This policy reform program was designed to gradually align domestic agricultural prices with international prices and to decouple agricultural policy by providing income assistance to farmers that was not directly linked to the farmers' production levels. The PROCAMPO program included eight crops: corn, dry beans, sorghum, wheat, soybeans, rice, barley, and cotton (PROCAMPO 1993).

Because of the Mexican government's strong intervention in so many levels of the domestic agricultural market, continued reform of agricultural policies would be expected to have a large impact on domestic producers and consumers. Mexico's food policy involves public organizations that directly affect agricultural production, exchange, distribution, consumption, and international trade and have a direct impact on the supply, price, and distribution of food in Mexico. Food policy in Mexico has had various objectives over the years, but the main focus has been to provide producers with an adequate standard of living and consumers with low-priced food (Sanderson 1992). This balance was maintained through price supports for commodities, indirect subsidies, import restrictions, market subsidies to processors and retailers, and consumer subsidies. The main policy instruments that have been used by Mexico's government for agriculture follow (Sanderson 1992).

1. Guaranteed price supports existed for many crops, but were discontinued for all crops except for corn and dry beans in 1989.
2. Negotiated price supports replaced most price supports beginning in 1989.
3. Consumer subsides were administered to processors and retailers.
4. Input subsidies were provided for fertilizer, investment credit, and other inputs.
5. Tariffs and quantity control measures were imposed on imports of agricultural commodities.

Research Problem and Objective

Changes in Mexico's domestic agricultural policy (PROCAMPO) and continued liberalization of trade through GATT and NAFTA will have strong effects on Mexico's agricultural production, consumption, and trade with the United States. The interrelationships of agricultural policy reform and trade agreements make policy analysis difficult for any specific policy. Previous studies have focused on NAFTA, for example, without explicitly incorporating GATT policies. Also, studies on the liberalization of domestic agricultural policy have not been based on PROCAMPO policy. Mexico's current trade policy does not strictly adhere to a specific trade agreement for all commodities. Thus, the major analytical issues with respect to Mexico's agricultural sectors are outlined as follows.

1. The effects of current trade policies under GATT, NAFTA, and PROCAMPO must be accounted for when analyzing trade policy that strictly adheres to the agreements as specified under NAFTA and PROCAMPO.
2. The effects on grain and livestock production and consumption in Mexico from implementation of PROCAMPO and NAFTA must be compared to current trade policies.
3. The effects on grain and livestock trade for Mexico from implementation of PROCAMPO and NAFTA policies must be compared to preceding domestic and trade policies prior to GATT.

The main objective of this study is to analyze the effects of Mexico's changing agricultural and trade policies on production, consumption, and trade in the grain and livestock sectors in Mexico. Mexico's current trade policies may overlap to some degree, and Mexico's domestic agricultural liberalization program (PROCAMPO) may include policies that overlap. Therefore, this study separates the effects of the PROCAMPO and NAFTA policy from the current trade policy of Mexico. These polices are also compared to the more restrictive pre-GATT policies.

To achieve this objective, this study analyzes the crop and livestock sectors within Mexico's economy and develops a domestic econometric supply and demand system based on economic theory. International agricultural trade is analyzed by deriving import demand and export supply relationships from the agricultural supply and demand model. Policy instruments for agricultural and trade liberalization are incorporated into the economic sectors developed in the model. Finally, changes in Mexico's production, consumption, and net trade patterns with the United States for grain crops and livestock are analyzed.

Research Procedures

The following procedures are employed in this research.

1. Developing an economic model for Mexico's livestock and crop sectors that includes supply and demand systems. An argument for determining the appropriate type of model is presented. An econometric model is developed that attempts to closely represent economic behavior and policies, given such constraints as data availability and reliability.
2. Deriving Mexico's import demand and export supply from the supply and demand system.
3. Incorporating policy instruments into the model for PROCAMPO, pre-GATT, and NAFTA economic policies.
4. Incorporating current trade and domestic policy as implemented by the government of Mexico into the model's baseline scenario.
5. Analyzing the impacts of PROCAMPO, pre-GATT, and NAFTA policies on changes in production, consumption, and trade in Mexico's grain and livestock sectors.
6. Analyzing welfare effects from PROCAMPO, pre-GATT, and NAFTA policies.
7. Analyzing an alternative scenario that depicts changes in Mexico's exchange rate.

Organization of the Study

This study is organized as follows. In Chapter, I present the research problem, objective, and procedures used in the study. Chapter 2 presents an overview of the relevant agricultural sectors in Mexico, focusing on seven commodities for cereal production: corn, dry beans, wheat, sorghum, soybeans, rice, and barley. An overview is provided for three livestock sectors: beef, pork, and poultry. Trade with the United States for each of these grain and livestock commodities is reviewed.

Chapter 3 presents an overview of Mexico's agricultural policy, trade, and marketing systems. Domestic agricultural policy is reviewed, including the PROCAMPO liberalization program. International trade policy for Mexico is reviewed, including pre-GATT, GATT, and NAFTA, and relevant U.S. agricultural policy is discussed.

Chapter 4 reviews agricultural models for Mexico, including a review of previous research in modeling the domestic economy and agricultural sector and specific studies on the livestock and grain sectors. This chapter also presents results from previous studies of GATT and NAFTA that have analyzed the impacts of these trade agreements on the U.S. and Mexican agricultural sectors.

Chapter 5 presents the theoretical development of the model used in this analysis. The chapter describes the rationale for determining which modeling technique is most appropriate for this research problem. For example, the chapter includes a discussion on the positive and negative aspects of using a partial equilibrium model as compared to a full equilibrium model and the relative advantages of using an econometric versus a computable general equilibrium model or a nonlinear programming model. Chapter 5 also includes a review of previous agricultural policy literature and provides a rationale for determining which theoretical approach is most appropriate in deriving supply and demand relationships for Mexico's agricultural sectors.

Chapter 6 presents the estimation results and simulation for this study. The data and data sources are presented, as are the specifics of estimating the model, such as the appropriateness of using a specific estimator and its properties. The estimated model, coefficients, and basic statistics are presented, and the model validation conducted for the study is presented. This chapter also presents a simulation of the statistical results and elasticities for the different agricultural commodities for the period estimated.

Chapter 7 presents the baseline development and incorporation of policies and policy instruments. The policy scenarios are evaluated for PROCAMPO, NAFTA, and pre-GATT, and an analysis of a currency exchange devaluation is compared to the baseline. Finally, Chapter 8 presents the summary and conclusions for this study.

CHAPTER 2. MEXICO'S CROP AND LIVESTOCK INDUSTRIES

This chapter presents the crop and livestock sectors incorporated into the agricultural model for Mexico. The seven grain crops included in the model are corn, wheat, dry beans, rice, sorghum, soybeans, and barley, and the three livestock sectors included in the model are cattle, hogs and pigs, and poultry. Production, consumption, trade, and the relative importance to agriculture in Mexico are presented for each commodity.

Corn

Corn is Mexico's largest crop, occupying over one-half of the total arable land. Ninety percent of corn production occurs in the Tapiliplato region in central Mexico and is concentrated in the states of Mexico, Jalisco, Chiapias, Puebla, Michoacan, and Guerrero. Eighty percent to 90 percent of total corn production is white corn for human consumption. In 1991, 78 percent of all Mexican farmers, or about 2.4 million farmers, produced corn. Of this total, approximately 2.2 million farmers raised corn on less than 5 hectares. The average area planted to corn per producer is 2.5 hectares (de Janvry, Sadoulet, and de Ande 1994), and two-thirds of all corn area is planted by small-scale farmers under the *ejido* system. Most of these farmers use a mixed planting of corn and dry beans or multiple-cropping of corn followed by dry beans (Mielke 1989).

In 1999, 8.4 million hectares of corn were harvested in Mexico. During the past 40 years, harvested corn area has gradually increased, from 6.00 million hectares in the early 1960s, to 8.15 million hectares in 1981, to 8.56 million hectares in 1993. During the 1980s, however, harvested area decreased to an annual average of 6.1 million hectares and did not increase again until the early 1990s. The decrease in area harvested that began in 1982 was the result of decreased funding for agricultural programs because of the financial crisis faced by the Mexican government. During the 1990s, harvested corn area averaged 7.7 million hectares per year.

The average corn yield in Mexico was relatively constant from the 1960s to the mid-1970s, at 1 metric ton per hectare. Between 1975 and 1994, corn yield increased by an average of 3.8 percent per year and has remained relatively flat since 1994. In 1999, the average corn yield was 2.26 metric tons per hectare, which is considerably less than the U.S. average of 8.44 metric tons per hectare. As previously noted, most Mexican corn producers operate on a very small-scale basis. As such, they do not readily incorporate new technologies. In addition, 87 percent of all corn production area is rain-dependent, and there are few irrigation facilities. Poor-quality seeds are used in over 60 percent of the area planted, and general management is not efficient (USDA 1992). In general, the land quality within the Tapiliplato area is not high. All these conditions contribute to the low corn yields in Mexico.

The main food staples within Mexico are corn and dry beans, and lower-income groups depend on these two staples for most of their calories and protein. Per capita corn consumption averages 155 kilograms to 160 kilograms per year (USDA 1999). Corn is normally consumed in the form of tortillas, which account for 75 percent of corn consumption, and most tortillas are consumed in large urban centers (USDA 1992). The corn processing industry consists of four major brand-name companies and many smaller-scale, semi-industrial producers. Seventy percent of all tortilla processors are served by these semi-industrial processors, comprised of approximately 20,000 small-scale corn millers, 15,000 integrated flour producers for dough and tortillas, and 19,465 tortilla producers (USDA 1995). About 40 percent of production is consumed on the farm by the producers' households.

The amount of corn utilized as feed for livestock was quite small prior to 1990s, averaging between 3 percent and 7 percent during 1960 through 1989. Since 1990, feed use increased to 26 percent during 1993 and 1994 and to 33 percent during 1996 through 1999 (USDA 1999). The pork and poultry industries create the largest feed-grain demand in Mexico, but corn usually makes up only a small proportion of the feed rations. The major commodities for feed rations are sorghum and soybean meal. Most cattle are range-fed and consume little, if any, grain. Mexico has more than 300 feed mills with a combined capacity of 14 million metric tons per year. Since the devaluation of the peso in late 1994, domestic corn has been less expensive than imported corn and mills have purchased domestic corn directly from producers for use in feed mills. The wet milling industry purchases corn primarily from the United States and has a production capacity of approximately 1.2 million metric tons per year (USDA 1995)

Mexico was primarily a net corn exporter prior to the 1970s and has primarily been a net corn importer since then. Between 1990 and 1999, corn imports averaged 3.3 million metric tons per year (USDA 1999). Corn imports represented more than 58 percent of total grain imports and accounted for almost one-fourth of total supply between 1985 and 1990 (USDA 1992). Corn imports fluctuate from year to year because most production is rain-dependent. Mexico's government food marketing company, CONASUPO, accounted for almost 50 percent of all corn imports from 1985 through 1990, with the domestic market importing the remainder (USDA, 1992). In the 1990s, the majority of corn imports (97 percent) originated in the United States (USDA 1999).

Dry Beans

Beans are an important crop in Mexico, and bean area is the second largest harvested area after white corn. More than 10 varieties of beans are produced, but the most prevalent are black, pinto, and pink beans. Approximately 70 percent of production is grown by small-scale, subsistence farmers on farms of one or two hectares. Approximately 65 percent of dry bean production is concentrated in the north central, pacific central, and central regions of Durango and Zacatecas. The state of Zacatecas is the largest producer, accounting for 30 percent of total production in 1994 (USDA 1995).

Dry bean production is highly variable because 90 percent of the farms are dependent upon rainfall. Dry beans are harvested twice a year, with 70 percent harvested from September to February and 30 percent harvested from March to July. In 1994, 2.805 million hectares were harvested, producing 1.462 million metric tons at a yield of 0.70 metric tons per hectare (SARH 1995). Since 1960, the harvested area for dry beans has fluctuated widely but does not exhibit any strong trends. The average area harvested from 1960 through 1995 was 1.744 million hectares, with a standard deviation of 269,000 hectares per year. The largest area harvested was 2.240 million hectares in 1966, and the smallest was 1.051 million hectares in 1979 (SARH 1995). Dry bean production has varied in line with changes in harvested area; however, in the 1980s and 1990s, dry bean production has exhibited greater volatility compared with production during 1960 through 1980. Dry bean yield increased by an annual average of 3.3 percent between 1960 and 1974. Since 1974, dry bean yields have fluctuated with no distinct trend, averaging 0.67 metric tons per hectare.

As noted, dry beans are one of the staples of the Mexican diet and provide a major source of protein for low-income families. Per capita dry bean consumption is about 15 kilograms per year. Dry beans are only used for human consumption, with 10 percent used for seed use or losses. Approximately 70 percent of the beans are marketed, and on-farm household consumption accounts for the other 30 percent (USDA 1992).

During the 1980s, Mexico imported about 15 percent of total supply, on average, but these imports fluctuate widely. During the decade, the low was 39,000 metric tons and the high was 400,000 metric tons. Prior to 1980, Mexico was historically a net exporter of dry beans; since then, Mexico has been a net importer. Most imports occur during seasonal shortages, which occur in January, February and March (USDA 1992).

Wheat

Wheat area harvested ranks fourth after corn, dry beans, and sorghum. Approximately three-quarters of total wheat production occurs in the northwest region of Mexico, which includes the states of Sonora, Sinaloa, Chihuahua, and Baja California. Modern technology, fertilizer, herbicides, pesticides, and large plots with irrigation systems are used for approximately two-thirds of production. A few of the largest and most sophisticated federal irrigation districts dominate wheat production (Sanderson 1986), and about 85 percent of wheat area is irrigated (Mielke 1991). Total harvested area has not increased significantly in Mexico during the past 40 years. The average area harvested during the past four decades was 787,000 hectares during the 1960s, 749,000 hectares during the 1970s, 911,000 hectares during the 1980s, and 874,000 hectares during the 1990s.

During the same 40-year period, total wheat production has increased by almost 3.8 percent per year. Average production during the 1960s was 1.701 million metric tons, compared 3.591 million metric tons during the 1990s. Increased wheat production has been driven by higher yields, which have increased from 1.86 metric tons per hectare in the early 1960s to 4.1 metric tons per hectare by the late 1990s. The average annual yield increase was almost 3 percent from 1960 through 1999. Mexico's wheat yields are among the highest in the world, largely as a result of the adoption of high-yielding semi-dwarf varieties and improved irrigation. Approximately 80 percent of the wheat produced in Mexico consists of soft winter varieties, with the remainder consisting of hard durum and white durum. Most of the wheat harvest is completed during April through July (USDA 1992).

Per capita consumption of wheat averaged 50 kilograms in the 1990s, with the urban middle class consuming the largest proportion. Total wheat consumption increased from 1.22 million metric tons in 1960 to 5.20 million metric tons in 1999, which is equivalent to 32 kilograms and 51 kilograms per capita, respectively. Consumption of wheat for food accounts for 80 percent of domestic production, and wheat accounts for about 20 percent of all grains in the human diet. Most food wheat is consumed in the form of bakery products and bread. Wheat is also used in feed rations in the northern states when the price is low enough to substitute wheat for sorghum (USDA 1992). In the 1980s, feed usage averaged 16 percent of domestic wheat consumption. Feed use consumption reached a low of 3 percent in 1980 and a high of 30 percent in 1986. In the late 1990s, wheat feed usage averaged 4 percent of domestic consumption, at 200,000 metric tons per year (USDA 1999).

Mexico has been a net importer of wheat since 1970. In the 1980s and 1990s, wheat imports averaged 14 percent and 29 percent of domestic consumption, respectively. Net imports have been highest in recent years (1995 through 1999), averaging 1.9 million metric tons per year, or about 35 percent of total domestic consumption (USDA 1999). During 1985-99, the United States maintained a 60 percent to 70 percent share of Mexico's wheat import market (USDA 1999). The major competitors against the United States in this market are Canada and the European Union.

Sorghum

Prior to 1996, sorghum had the third-largest area harvested after corn and dry beans, but sorghum surpassed dry beans in terms of area harvested in 1999, at 2 million hectares (USDA 1999). The state of Tamaulipas accounts for 40 percent of production, and the states of Jalisco, Michoacan, and Guanajuato combined account for almost 50 percent of sorghum production. Sinaloa accounts for the remaining 10 percent. Tamaulipas has two sorghum crops per year, with the fall/winter crop accounting for approximately 80 percent of the harvest. This crop is planted in February and harvested in June. Ninety percent of Tamaulipas' sorghum production is concentrated in the four northern districts. The fall/winter crop is limited by water supplies (USDA 1993-2000). Slightly less than half of the sorghum produced is grown on smaller farms such as *ejidos* and private farms. Larger farms (5 hectares or greater) account for the other half of production.

Sorghum is quite variable, since one-third to two-thirds of production is grown on rain-fed land. Sorghum area harvested has increased significantly from the early 1960s, when it averaged 200,000 hectares, to the late 1990s, when it averaged 2.0 million hectares. In 1998 and 1999, 1.95 million hectares and 2.00 million hectares were harvested, respectively (USDA 1999). Average yields have increased from 2.3 metric tons per hectare during 1960-65 to 3.16 metric tons per hectare during 1995-99. Total sorghum production has increased from 290,000 metric tons in 1960 to 6.50 million metric tons in 1999 (USDA 1999).

Sorghum is used as a feed grain for pork and poultry, and increased sorghum demand is a result of expanding poultry and pork production (USDA 1992). Commercial pork production is located in the Bajio region, just north of Mexico City, where over 60 percent of the sorghum supply is used as feed grain for pork. Sorghum is sometimes substituted with lower-priced corn imported from the United States or wheat, when wheat prices are low enough.

Mexico's sorghum imports averaged 103 percent and 45 percent of production for 1990-94 and 1995-99, respectively, of which 98 percent was imported from the United States. Sorghum imports in the 1990s have been relatively large, averaging 3.162 million metric tons per year (USDA 1999). Prior to 1988, imports were highly variable. Sorghum imports are highly correlated to other feed markets in Mexico, such as wheat and corn, which may be attributable to the effects of rainfall conditions on these crops.

Soybeans

The rank of soybean area harvested decreased from fifth in the 1980s to almost seventh by the late 1990s. Most production occurs on large, irrigated, commercial farms utilizing modern production techniques and inputs. Soybeans are usually harvested in September and double-cropped with winter wheat (USDA 1992). The majority of soybeans are produced in the northeastern state of Tamaulipas and the northwestern states of Sonora and Sinaloa, which account for approximately 92 percent of total soybean production (USDA 1993-2000).

Soybean area harvested increased from an average of 55,000 hectares in the mid-1960s to an average of 300,000 hectares by the late 1980s and then decreased to an average of 90,000 hectares by the late 1990s (USDA 1999). The decrease in area harvested from 1995 through 1999 was mostly due to poor weather conditions, lack of water in Sonora and Sinaloa, and a higher-than-normal infestation of white flies (USDA 1993-2000).

Yields have varied between 1.6 metric tons and 2.0 metric tons per hectare from the 1960s to the mid-1990s, with no distinct trend. In recent years (1995-99), yield averages have been much lower, at 1.41 metric tons per hectare, due to poor weather conditions and white fly infestations. Mexico's yields are less than yields in the United States, which average 2.5 metric tons per hectare. Soybean production averaged 600,000 metric tons and 143,000 metric tons for 1980-94 and 1995-99, respectively (USDA 1999). Dry weather conditions have significantly contributed to decreased soybean production as producers switch to crops that use less water, such as dry beans (USDA 1993-2000).

The primary demand for soybeans is derived demand for meal and oil. Crush demand is determined by the pork and poultry industries and the price of competing oils such as rape seed (USDA 1992). In Mexico, 70 percent of the oilseed meal consumed comes from soybean meal, which has expanded with increasing pork and poultry production. Soybean meal consumption was 600,000 metric tons in the 1970s and increased to 2.385 million metric tons by the 1990s (USDA 1999). Soybean meal consumption is also affected by the prices of wheat and corn, which are used as substitutes in the feed industry.

Consumption of soybeans has increasingly exceeded production, resulting in increasing imports. Imports averaged 300,000 metric tons, 1.140 million metric tons, and 2.554 million metric tons during the 1970s, 1980s, and 1990s, respectively (USDA 1999). Whole oilseeds are imported, as opposed to the finished products of oil and meal, because of lower transportation costs and economic benefits to domestic processors. Imports vary widely by year, depending on domestic production, feed demand, prices of substitute commodities for feed production, and government policy. The United States is the primary supplier of soybeans to Mexico, with market shares averaging 74 percent in both 1998 and 1999 (USDA 2000).

Rice

Rice production in Mexico is small and accounts for only 1 percent of the total grain area harvested in Mexico. Only long-grain rice is produced in Mexico, and production is concentrated in the gulf states of Campeche and Veracruz (USDA 1993-2000). Yield has increased at an average rate of 2.2 percent per year since the early 1960s, with milled yields increasing from 1.50 metric tons per hectare to 3.33 metric tons per hectare in the late 1990s (USDA 1999). Recently, the average area harvested has declined, from 150,000 hectares to 75,000 hectares during 1990-95. The Mexican rice market was liberalized in 1990, and rice production fell as a result of increased costs of inputs and low producer prices relative to price of substitute crops (USDA 1993-2000). Rice area increased to 100,000 hectares in late 1990s due to competitive prices.

Rice production has generally fluctuated because of the availability of irrigation water, which is dependent upon rainfall. Most rice production utilizes irrigation technology, which accounts for 70 percent of production. Modern technology used in rice production accounts for the continued increase in yields. Fertilizer and improved hybrid seeds are used on 70 percent to 86 percent of cultivated area (USDA 1992). Most rice is planted in May and June and harvested in November and December.

Rice is common in many Mexican dishes, and it is one of the most expensive food grains. Per capita consumption of rice averaged 5.4 kilograms during 1970-94, but gradually increased to 5.9 kilograms by 1999 (USDA 1999). Very little rice is consumed on the farm, and most production is sold to the market, where 65 percent is sold directly to private mills (USDA 1992).

Imports of rice averaged 26,000 metric ton during 1960-87 but increased to 290,000 metric tons for the 1988-99 period (USDA 1999). Beginning in 1988, Mexico has consistently imported rice because production has not kept up with consumption, and this trend is expected to continue.

Barley

Barley is ranked fifth in area harvested, after wheat. Area harvested averaged 250,000 hectares for most of the 1980s and 1990s. In the late 1990s, barley surpassed soybeans in terms of area harvested. The production of barley has increased from 400,000 metric tons in the early 1980s to around 500,000 metric tons in the 1990s. Yields averaged 1.4 metric tons per hectare to 1.5 metric tons per hectare in the early 1980s and 1.95 metric tons per hectare in the 1990s (USDA 1999). Yields increased because of improved seed varieties, new production technologies, and increased use of fertilizer. However, yields remain low in comparison to yields in the United States, which averaged 3.2 metric tons per hectare in the late 1990s (USDA 1999). Production of feed barley is concentrated in northern Baja California, and production of malting barley is concentrated in the central Bajio region in the states of

Hidalgo, Puebla, and Tlaxcala. Most barley (80 percent) is harvested in May and June, and the remainder is harvested during September through February (USDA 1992).

Barley's derived demand comes from the brewing industry and livestock and poultry sectors (USDA 1992). Barley for the brewing industry has maintained the greatest demand in Mexico, averaging 460,000 metric tons per year in the 1990s and accounting for 70 percent of total barley consumption. Feed demand for barley has increased greatly, from an average of 35,000 metric tons during the 1960s and early 1970s to an average of 228,000 metric tons by the late 1990s (USDA 1999).

Mexico imports both malting barley and feed barley. Imports fluctuate with fluctuations in production, depending upon rainfall levels. In the 1970s, the lowest imports were zero and the highest imports were 206,000 metric tons. The 1980s had a low of 5,000 metric tons and high of 140,000 metric tons. Recent imports have been the highest, with 350,00 metric tons imported in 1999 (USDA 1999). Canada has supplied most of the barley imported by Mexico.

Cattle and Beef

The Mexican cattle industry consists of three categories: dairy cattle production in the north, beef production and feeder cattle exports in the north, and the traditional combination of beef and dairy production in the central and southern states (Yates 1981). The majority of beef in Mexico is produced on traditional grazing pastures and grass lands, which account for about 60 percent of Mexico's total agricultural land (Yates 1981). Beef production is nearly evenly distributed among the north, central, and southern regions of Mexico, at 34 percent, 36 percent, and 30 percent, respectively (Bierlen and Hayes 1994).

The distinction between dairy and beef production is not clear in traditional herds. The cattle are raised for beef but also provide dairy products in the interim, which contributes to the poor efficiency in the traditional beef production system. Traditional breeds are Zebu and Criollo (Yates 1981). Calving rates in traditional herds are 50 percent to 60 percent, and fertility rates are about 33 percent. Feeder cattle exports from the northern region consist of Herefords and Brahman breeds plus Exotics (Bierlen and Hayes 1994). Feedlots with grain-fed beef exist only in the northern region, whereas the central and southern regions produce strictly grass-fed beef. Grain-fed beef production is increasing in the north, specifically in the state of Sonora.

Beef consumption in Mexico is usually limited to higher-income households, and beef is considered a luxury good. Middle- and lower-income households usually cannot afford grain-fed beef. Beef consumption in Mexico has averaged 21 kilograms per capita since 1990, which is about half the U.S.

consumption level. In low-income areas, most beef is purchased in small butcher stores. In the middle- and upper-income areas, larger meat shops and supermarkets carry a greater variety of meats and cuts (Bierlen and Hayes 1994).

Mexico exports a large number of light weight feeder cattle to the United States and is the largest exporter to the United States of live cattle and edible tallow. Mexico's feeder cattle exports averaged 1.12 million head during 1990-95, which is a large increase from the 1980s average of 670,000 head. Exports of feeder cattle to the United States were lower during 1996-99, averaging 685,000 head, or the lowest levels since the mid-1980s (USDA 1999). The decrease in exports during 1996 and 1997 was mostly due to the liquidation of cow herds during drought conditions. U.S. imports of feeder cattle from both Mexico and Canada average about 7 percent of the U.S. feeder cattle supply.

Mexico imported an average of 134,000 head and 161,000 head of live cattle from the United States during 1990-95 and 1996-99, respectively (USDA 1999). These cattle were breeding stock or fed cattle for slaughter, not feeder cattle. Mexico increased imports of beef after 1988, averaging 92,000 metric tons and 165,000 metric tons during 1989-95 and 1996-99, respectively (USDA 1999).

Pork

Pork production is concentrated in the central and southern regions of Mexico, which are located near the major domestic consumption centers. Pork production has changed in the past decade, becoming more concentrated and more vertically integrated. Approximately two-thirds of Mexico's pork is produced under modern confinement systems, which is common for commercial pork production. Modern production facilities utilize highly productive breeds such as Duroc, Hampshire, and Yorkshire (Bierlen and Hayes 1994). The state of Sonora has the highest concentration of modern facilities, at 96 percent (Bierlen and Hayes 1994). The typical feed consists of balanced feed rations.

In 1980, the two leading crops comprising the primary feed grains used in rations were sorghum and oleaginous paste (soya) (Sanderson 1986). Also included in pork feed rations, but in smaller proportions, are cottonseed, safflower, and sesame. Most of the feed protein comes from soya, which is complemented by fish protein. Corn and wheat are also utilized when it is profitable to do so.

One-third of Mexico's pork production occurs in traditional backyard farm operations. Backyard pork production does not utilize modern breeds or modern inputs such as compound feed and nutrients. Feeding out native breeds using a variety of forages takes more than a year, compared to the modern technological approach which averages six months to a year. Backyard pork production is centered around Mexico City (Bierlen and Hayes 1994).

Hog numbers and pork production increased by almost 5 percent annually from 1960 to 1982. Hog numbers then declined by 9 percent annually between 1982 and 1990 (USDA 1999). The large decline in numbers can be attributed to Mexico's economic problems, beginning in 1982; the elimination of a sorghum subsidy in 1985; increases in the cost of production; hog cholera; and a decrease in the adoption of new technology (Bierlen and Hayes 1994). Hog, sow, and pig numbers averaged 9.02 million head from 1989 to 1992 and 11.29 million head from 1993 to 1999 (USDA 1999).

Pork consumption is more prevalent among Mexico's middle- and lower-income groups than is beef consumption, whereas beef is most frequently consumed by the upper economic class. Per capita pork consumption declined from an early 1980s average of 16 kilograms per year to an average of 9 kilograms to 10 kilograms per year over the past ten years as consumers have substituted less expensive poultry meat for pork. Most pork is purchased from local butchers with no grading standard, and consumers generally use sight and smell to select the product. Mexicans consume more variety meats, such as tripe, heart, and other internal organs, than do U.S. consumers. Offal is often preferred because of the price advantage and is served in a large number of Mexican dishes (Bierlen and Hayes 1994).

Mexico's pork imports have increased from almost 1,000 metric tons in the mid-1980s to an average of 90,000 metric tons for the late 1990s. Mexico is the second largest pork importer of U.S. pork, after Japan. Pork exports consist of variety meats, offal, lard, live hogs, cured products, and other pork products. The United States imports little pork from Mexico.

Poultry

Poultry production has evolved into a modern industry with only a few large-scale producers using modern, confined-feeding production systems. Approximately 75 percent of all poultry is produced under this system, with the remaining 25 percent produced in backyard operations. The confined-feeding systems depend upon balanced feed rations. The poultry industry has increasingly become vertically integrated, including feed mixing and poultry processing (USDA 1992). As of 1986, 2 percent of Mexico's broiler operations produced 60 percent of the nation's poultry meat, with 2,000 birds to 10,000 birds produced in the average broiler operation (USDA 1996). Bierlen and Hayes (1994) state that the poultry industry is the most dynamic and well-organized of the three meat sectors. This industry has the highest levels of horizontal and vertical integration and the highest productivity of the three industries.

According to The WEFA Group (1993), Mexico's integrated poultry producers have a smaller market share than do producers in the United States or Canada. WEFA also states that about 80 percent of poultry is purchased from local markets as whole chickens, and not through supermarket chains.

Poultry production is located in the central region of Mexico, with ten states producing two-thirds of the poultry meat. Seven of these ten states are located close to Mexico City (Bierlen and Hayes 1994). Poultry meat production has increased from 83,000 metric tons in 1964 to 1.809 million metric tons in 1999. The annual rate of production growth was 9.2 percent during 1964-99. The positive growth rate has decreased during each decade since 1964; for example, from 1964 to 1974 the annual growth rate was 15.7 percent, from 1974 to 1984 the growth rate was 6.2 percent, and from 1995 to 1999 the growth rate was 3.8 percent (USDA 1999). Only the years 1986 and 1987 showed declines in production. Macroeconomic problems beginning in 1982 and the elimination of feed subsidies to poultry producers in 1985 may have contributed to these declines.

Consumption of poultry and eggs is quite common to all social classes and provides a low-cost source of protein to lower-income groups in Mexico. Annual per capita consumption of poultry has increased from an average of 9 kilograms in the late 1980s to about 17 kilograms in 1999. Early in the 1990s, poultry consumption surpassed pork consumption. Per capita pork consumption has averaged 10 kilograms per year for the past decade. Beef consumption has held steady, at around 19.5 kilograms to 20 kilograms per capita per year, since the early 1990s (USDA 1999).

Mexico is among the top five importers of poultry from the United States and was the leading importer of U.S. turkeys in the 1990s. Poultry imports from the United States consist of chicken and turkey meat, day-old chicks, hatching and table eggs, and egg products (USDA 1992). Mexico's poultry imports were relatively constant during 1980-87, at an average of 13,000 metric tons per year. In 1988, poultry imports increased to 54,000 metric tons and continued to increase at a rate of 14.4 percent annually from 1988 to 1999. Poultry imports in 1998 and 1999 were 231,000 metric tons and 238,000 metric tons, respectively (USDA 1999). In 1997 and 1998, Mexico was the third largest export market for U.S. poultry meat, after Russia and Greater China. In 1997 and 1998, the United States exported 207,000 metric tons and 244,000 metric tons of poultry meat to Mexico, valued at U.S. $227 million and $231 million, respectively, and representing 9.3 percent and 10.6 percent, respectively, of the total value or U.S. poultry meat exports (USDA 2000).

CHAPTER 3. AGRICULTURAL POLICY

Mexico's government intervention policies in agriculture increased in the 1930s under the presidency of Lazaro Cardens. Land reform was implemented on a large scale, and a number of key institutions were established that made the government responsible for maintaining economic stability, growth, and the distribution of wealth. Since then, the state food agency has been actively involved in all aspects of agricultural production, processing, distribution, and trade in Mexico. The state food agency has changed names many times since the early 1930s but has been called CONASUPO since 1960.

This chapter is divided into four sections. The first section provides a short history of food policy in Mexico from the 1980s to the present, including the PROCAMPO liberalization program and recently developed policy. The second and third sections outline Mexico's international trade policy under NAFTA and GATT. The final section presents U.S. trade policy affecting trade with Mexico.

Food Policy in Mexico

As noted, this section provides a brief history of food policy in Mexico. The portion food policy history reviewed begins in 1982 under the presidency of Miguel de la Madrid and concludes with current policy.

The Presidency of Miguel de la Madrid (1982-1988)

Policies adopted in the 1970s and early 1980s made the Mexican economy quite vulnerable to external shocks from oil markets and foreign capital markets. Beginning in 1982, Mexico faced its most severe economic crisis since 1930. Oil prices dropped, and Mexico was unable to finance the budget deficit incurred during the previous two presidencies from 1970 to 1982. Public debt had increased from U.S. $22.9 billion in 1977 to $53 billion in 1981 in real dollars. At the same time, the private sector had increased borrowing from U.S. $2 billion to $18 billion. The previous ease of financing was caused by large petro dollar deposits in international financial markets. In 1982, inflation was almost 100 percent, and the economic growth rate was -0.6 percent (Brothers and Wick 1990).

The effects of the economic crisis on Mexico's food policy during the presidency of Miguel de la Madrid involved several different stages. Because of the severity of the crisis and potential unrest, the government's food policy program was used to help alleviate the situation by functioning as a primary relief agency during the initial years of the crisis. The government subsidized prices to consumers and maintained sufficient supplies by importing grains. CONASUPO continued to maintain its funding from the federal government during the initial years of the economic crisis. Much of the organization's work during this time was to maintain imports of basic food staples and to expand its network of retail stores. Between 1982 and 1984, for example, the number of stores increased by 39 percent, from 11,291 to 15,699 stores. In addition, more stores were located in rural poor areas. By 1988, 70 percent of the stores were located in rural areas. CONASUPO continued to run a deficit by selling basic food staples to the public at a lower price than the combined cost of the price paid to farmers for the commodities and the cost of processing. Because of government financial problems, subsidies were gradually cut to consumers and more specifically targeted to poorer families in 1983 and 1984.

In 1986, the Tortibonos program was initiated by CONASUPO to target families earning less than two times the minimum wage and giving them coupons with which to purchase subsidized tortillas. In the 1980s, real guaranteed prices for commodities declined and the government provided less investment, in real terms, to rural areas beginning in 1982. Inflation was high—in the double and triple digits—and the guaranteed real prices for beans, corn, and wheat declined by as much as 60 percent to 70 percent through the late 1980s. This price decline contributed to lower production in basic grains for Mexico. Domestic consumption exceeded grain production, and imports were high during the 1980s. Corn imports, for example, averaged 3 million metric tons per year, or almost triple the volume of imports during the previous decade. This period also contributed to further financial indebtedness for the Mexican government (Ochoa 1993).

During the 1980s, Mexico began to move toward less inward-oriented economic and trade policies. This transition was due in part to the debt crisis of 1982, lower petroleum prices in 1986, and pressure from economic lenders. Tariffs and nontariff barriers were reduced in 1983 as the Mexican government began to alter its import policy. This process was accelerated when Mexico joined the GATT in 1986 (Mielke 1989).

The Presidency of Carlos Salinas de Gortari (1988-1994)

After taking office in 1988, President Carlos Salinas de Gortari began to privatize and liquidate state agencies at a fast pace, including CONASUPO, the state food agency. In October 1989, Salinas announced that privatization would be aimed at making the government more responsive to the poorest sectors of the population. These decisions were based on a number of cost-benefit studies which concluded that current food policy programs were using resources inefficiently, benefiting neither producers nor consumers, and expensive for the government to maintain. President Salinas wanted to encourage private and foreign investment in agriculture and to have the government participate in the marketplace as a regulator, rather than participating directly as it had done in the past. A number of urban stores were closed and many processing facilities were sold or shut down. Beginning in 1989, grains purchased with guaranteed support prices were limited to corn and dry beans, both of which main food staples. Specifically targeting the poor involved placing greater emphasis on subsidizing the food staples consumed by the poorest segments of the population, and subsidized commodities included milk and tortillas for those living in the rural areas and for families with marginal incomes. Warehouses were opened in rural areas to serve isolated populations of lower-income families (Ochoa 1993).

The policies implemented to assist the poor were run in cooperation with the National Solidarity Program (PRONASOL), a new program announced by President Salinas in his inaugural address on December 1, 1988. This social welfare program sought to develop health, education, housing, nutrition, and basic infrastructure for the poorest sectors of Mexico's population. Some food policy changed under PRONASOL; for example, tortillas were given directly to the poorest families in place of the previous system of distributing tortilla coupons that could be used to purchase tortillas at a discounted price. At the same time, tortilla prices were being gradually liberalized to the general public (Ochoa 1993).

President Salinas faced an almost bankrupt public sector. In addition, production of major staples did not satisfy domestic demand, agricultural pricing and distribution systems were ineffective, and domestic farm prices were supported at levels that were much higher than international prices (Sanderson 1992). In 1991, for example, the international price of corn was U.S. $95 per metric ton and the Mexican price was $238 per metric ton, or 2.5 times higher. One of the major achievements of President Salinas was the linking of rural development and domestic food policy to international trade policy. This new era officially began in the early 1990s with the declaration of free trade negotiations between the United States and Mexico. As noted, prior liberalization of Mexico's economy had already begun, so this linkage was a continuation of the liberalization policies being enacted in Mexico.

The following sections discuss Mexico's agricultural policy for specific grains and livestock. These policies include agricultural price supports, agreement prices, import licenses, input subsidies, marketing subsidies, consumer subsidies, feed subsidies, and land tenure.

Agricultural Price Supports

Production decisions have been directly affected by guaranteed price supports in Mexico. Guaranteed price supports were established in the late 1930s for corn, dry beans, and wheat. These price supports were temporarily discontinued from the late 1940s to the early 1950s. In the early and mid-1960s, guaranteed prices were established for rice, sorghum, soybeans, saffron, cottonseed, sesame seed, and copra. In the early 1970s, guaranteed prices were established for malted barley and sunflower. Table 3.1 presents the years during which guaranteed grain prices have been established and eliminated in Mexico.

The government sets the uniform guaranteed prices at which CONASUPO purchases commodities from producers (Ochoa 1993). A reference price is announced before planting, and the guaranteed price is announced shortly before or during harvest (Rempe 1993). Guaranteed prices for 1960 through 1995 are presented in Table 3.2.

Producers can sell their products to the government or in the private market. CONASUPO purchases of total grain production range from 0 to 50 percent, depending upon the commodity, current policies, and economic conditions. Table 3.3 shows CONASUPO purchases of corn, wheat, and dry beans as a percentage of production. As shown, wheat had the highest percentage of production purchased by CONASUPO, followed by dry beans and corn, respectively. The percentage of wheat production purchased by CONASUPO averaged 54 percent, 35 percent, and 37 percent during the 1960s, 1970s, and 1980s, respectively. The percentage of dry bean production purchased averaged 8 percent, 18 percent, and 32 percent during the 1960s, 1970s, and 1980s, respectively. The percentage of corn production purchased averaged 17 percent, 14 percent, and 17 percent in the 1960s, 1970s, and 1980s, respectively.

Tariffs and Import Licenses

The Mexican government maintains import quotas as a supply management tool to maintain targeted domestic farm prices. Import licenses are usually issued to the public after harvest, and most of the domestic crop is purchased by the private sector and CONASUPO. To obtain a license, a private importer or Mexico's food parastatal under CONASUPO must show that domestic supplies are being purchased for a price of not less than the government target price. The government usually grants

Table 3.1. Year of establishment and elimination of guaranteed grain prices

Grain	Year Established	Year Eliminated
Wheat	1937	1989
Corn	1938	1995
Dry Beans	1938	1995
Rice	1960	1989
Sorghum	1965	1989
Soybean	1966	1989
Barley	1971	1989

Source: Ochoa 1993.

Table 3.2. Government guaranteed prices for major grain commodities (pesos per kilogram)

Year	Wheat	Corn	Dry Beans	Rice	Sorghum	Soybeans
1960	913	800	1,500	850	559	—
1961	913	800	1,750	900	559	—
1962	913	800	1,750	900	574	—
1963	913	940	1,750	1,050	574	—
1964	913	940	1,750	1,100	625	—
1965	800	940	1,750	1,100	625	—
1966	800	940	1,750	1,100	625	1,600
1967	800	940	1,750	1,100	625	1,600
1968	800	940	1,750	1,100	625	1,600
1969	800	940	1,750	1,100	625	1,450
1970	800	940	1,750	1,100	625	1,300
1971	800	940	1,750	1,100	625	1,600
1972	800	940	1,750	1,100	725	1,800
1973	800	1,200	2,150	1,100	770	2,700
1974	1,300	1,500	6,000	3,000	1,100	3,300
1975	1,750	1,900	4,750	3,000	1,600	3,500
1976	1,750	1,340	5,000	3,000	1,760	3,500
1977	2,050	2,900	5,000	3,100	2,030	4,000
1978	2,600	2,900	6,250	3,100	2,030	5,500
1979	3,000	3,480	7,750	3,720	2,335	6,400
1980	3,550	4,450	12,000	4,500	2,900	8,000
1981	4,600	6,550	16,000	6,500	3,930	10,800
1982	7,278	9,525	21,000	9,000	5,200	14,800
1983	16,100	17,600	31,250	19,300	12,050	30,350
1984	26,150	29,475	46,425	27,550	21,000	56,000
1985	38,500	48,400	120,000	43,950	30,350	88,000
1986	71,500	85,500	202,000	98,000	60,000	165,000
1887	120,000	202,500	437,000	238,000	142,000	408,000
1988	310,000	345,000	732,750	238,000	225,000	408,000
1989	372,500	402,745	986,973	238,000	360,000	986,000
1990	—	618,000	1,750,000	—	—	—
1991	—	595,000	2,100,000	—	—	—
1992	—	625,000	2,100,000	—	—	—
1993	—	700,000	2,100,000	—	—	—
1994	—	625,000	1,800,000	—	—	—
1995	—	550,000	1,800,000	—	—	—

Source: Ochoa 1993.

Table 3.3. CONASUPO purchases of grain as a percentage of production

Year	Wheat	Corn	Dry Beans
1960	40.0	13.0	0.1
1961	53.5	9.5	6.0
1962	59.3	11.5	14.4
1963	69.5	12.7	12.3
1964	51.1	19.4	0.0
1965	67.9	20.8	11.0
1966	52.1	19.5	13.0
1967	51.9	22.2	10.2
1968	39.7	19.6	6.3
1969	51.4	17.4	6.5
1970	43.3	13.4	3.6
1971	37.3	15.7	10.6
1972	35.1	15.6	15.7
1973	44.1	9.3	0.3
1974	26.1	9.9	2.4
1975	38.1	4.1	35.5
1976	44.4	12.1	32.6
1977	1.9	14.1	32.2
1978	43.3	16.5	17.9
1979	34.3	23.1	28.2
1980	42.0	7.0	14.2
1981	39.9	19.7	35.8
1982	54.5	32.2	50.0
1983	53.2	12.3	41.4
1984	41.9	19.5	42.1
1985	34.2	15.0	15.8
1986	45.9	20.8	23.9
1887	30.1	14.5	45.4
1988	15.4	16.4	30.5
1989	8.5	16.0	17.6
1990	8.3	15.9	9.6

Source: Ochoa 1993.

permission to import only after domestic production is marketed or if imports serve some other national interest (Robinson, et al. 1991; Mielke 1989, 1990). Tariffs are not usually imposed on imports with license requirements because the licenses effectively restrict imports to the desired quota level established by the government. Commodities with licenses have been changed to tariff-rate quotas, as discussed in the sections on NAFTA and GATT that appear later in this chapter. Tariffs on many agricultural commodities have been continuously reduced through the 1990s.

Input Subsidies

Production decisions have also been affected by input subsidies from the Mexican government. Subsidies used to stimulate agricultural production have been credit, irrigation water, fertilizer, improved seeds, crop insurance, pesticides, electricity, and fuel.

Prior to 1980, the percentage of subsidized credit to agriculture was small, accounting for only 13 percent of the value of crop production, and only 30 percent of producers had access to credit. It was not until 1980-82 that subsidized credit was reoriented toward grain production (Austin and Esteva 1987). Credit to producers for 1982, 1989, and 1982-89 was valued at 33 percent, 17 percent, and 11 percent, respectively (measured in producer subsidy equivalents), of the value of crop production. Corn production received more than 50 percent of the credit, and producers of other grains received credit for dry beans, 17 percent; sorghum, 16 percent; wheat, 10 percent; and soybeans, 4 percent. Credit subsidies have been reduced as economic reform has progressed. As of April 1989, all interest rate controls have been removed and only low-income producers can obtain subsidized credit (Grennes et al. 1991).

Irrigation was the second largest input subsidy (measured in producer subsidy equivalents) offered to producers during 1982-89, representing more than 5 percent of the gross value of crop production. Fertilizer was the third largest form of input subsidies, representing 4 percent of the value of crop production in terms of producer subsidy equivalents. Domestic fertilizer prices were increased by the Mexican government in 1990 and 1991 to align with international prices. Crop insurance is the fourth largest input subsidy, representing about 3 percent of the value of crop production during 1982-89. In 1990, insurance was based on nonsubsidized premiums and voluntary participation (Grennes et al. 1991). Certified seeds have been provided at subsidized rates, but this policy was been restructure, and certified seeds are now provided at market price (Grennes et al. 1991).

Marketing Subsidies

The Mexican government has provided marketing subsidies in the form of wholesaling, retailing, and warehousing of commodities. CONASUPO has seven affiliates through which the government is able to purchase, store, and distribute a variety of commodities through government stores (Pinon-Jimenez 1986).

CONASUPO eliminated marketing support for all commodities except corn and dry beans in 1989 and replaced the supports with agreement prices. The food distribution network, including wholesaling, warehousing, and retailing, has not been eliminated. This system will continue to focus on poorer and smaller-scale producers, but warehousing will also be provided to the private sector and to producer organizations. Warehousing can be used for commodity storage, distribution of fertilizers and pesticides, and operation of procurement centers in remote areas. Private traders are charged for services at commercial rates (Grennes et al. 1991).

Food and Feed Subsidies

CONASUPO sells commodities to processors at prices lower than the producers' guaranteed price, and the foods are then passed on to consumers at a lower cost compared to the true market value. The Mexican government also provides direct subsidies to consumers with lower-income households. Food coupons were introduced in 1987 with the objective of targeting specific subsidies toward these households.

Corn has two types of subsidies: a corn flour subsidy and a direct subsidy to low-income households. Corn flour is subsidized with a direct subsidy to flour producers. Corn is sold to flour producers at a subsidized price, which is lower than the guaranteed price, cost of transportation, and storage cost paid by CONASUPO. The lower cost to flour producers is passed on to consumers through lower-priced corn tortillas.

Low-income consumers are also subsidized directly through nutritional policies directed at lower-income households. This subsidy has included tortillas, flour, and dough. In 1986, 4.5 million people were able to obtain tortilla stamps provided to low-income families to obtain 1 kilogram of free tortillas per day from manufacturers. CONASUPO reimbursed the manufacturers for the tortillas (Grennes et al. 1991; USDA 1992). In 1994-95, for example, CONASUPO purchased corn at the reference price of 715 new pesos (NP) per metric ton and resold it to semi-industrial processors in Mexico City at NP$225 per metric ton and to semi-processors outside of Mexico City for NP$425 per metric ton. Because a larger concentration of poor people live in Mexico City, the government subsidy to producers is greater in that area (USDA 1995).

Dry beans are purchased by CONASUPO from producers at the guaranteed price or imported by CONASUPO at the world price. The beans are sold to consumers at controlled prices, which are subsidized. CONASUPO incurs the cost of subsidization. Urban consumers purchase dry beans at controlled prices from urban markets, but rural consumers can benefit through direct bulk sales (Grennes et al. 1991; USDA 1992).

Wheat has been subsidized for consumers by CONASUPO by providing direct consumer subsidies on wheat flour and wheat bread. CONASUPO sells wheat to processors at prices below the purchase price, thus providing a direct subsidy to flour millers, which is then passed on to consumers through fixed prices at wholesale and retail outlets.

Feed inputs have been provided to the livestock sector, consisting of a balanced feed mix provided to producers at prices lower than market prices. Feed inputs have been distributed for milk (30 percent), egg (26 percent), pork (18 percent), poultry (16 percent), and beef (10 percent) production (Grennes et al. 1991).

Land Tenure

The Mexican government has been actively involved in agriculture since the Mexican revolution, when land reform was incorporated through Article 17 into the 1917 constitution. Prior to 1945, Mexico's primary activities in agriculture have been agrarian reform. Land reform was initiated to restore land improperly taken from peasant communities in the late nineteenth century to the rightful owners. Landless farmers were given rights to land as a community, as members of an *ejido*. The *ejido* was created as a communal unit holding title to land. The land could then be allocated to individuals or maintained as communal land. Two basic types of *ejidoes* exist: individual and collective. As of 1960, individual *ejidoes* made up 95 percent of all *ejidoes* (Eckstein 1978). In 1980, 83 millions hectares existed as *ejidoes* and 82 million hectares existed as private land as reported by United Nations Food and Agriculture Organization (Rudolph 1985).

Ranch size was restricted to the number of hectares that could support 500 head of cattle by the Agrarian Reform Code. If ranchers attempted to improve the land, the land could be reclassified as cropland, upon which additional restrictions are imposed. Cropland ownership was restricted to 100 hectares of irrigated land and 200 hectares for dry land.

Recently, *ejidal* law has changed significantly. In November 1991, President Salinas proposed radical changes by permitting privatization and the dismantling of much of the *ejidal* system. February 1992 brought changes in land tenure that allowed private owners to own large parcels of land (Rosson et al. 1993).

PROCAMPO

PROCAMPO, a domestic support program for the Mexican farm sector, was announced on October 4, 1993, by President Salinas. This program would gradually align domestic prices with international prices, and direct income support was made eligible to producers as compensation for low prices. The crops included under PROCAMPO are corn, dry beans, wheat, sorghum, rice, soybeans, barley, safflower, and cotton. This program replaced the previous system of price supports and direct payments with a completely decoupled direct income support program to producers, and thus does not distort production decisions and trade. PROCAMPO was recognized as a permanent institution by President Ernesto Zedillo under the Rural Alliance program, announced on October 31, 1995 (USDA 1995).

Guaranteed and agreement price supports for agricultural products were phased out over a two-year transition period for all crops except rice and cotton. Phase-out began during the 1993/1994 marketing year. Transition prices for rice and cotton were set at the average market price. Direct payments per hectare were phased in during this same period. PROCAMPO will be gradually phased out over 15 years, beginning in 1995. Payments are fixed in real terms for a period of 10 years and then phased out in equal installments during years 11 through 15 (PROCAMPO 1993).

Income support to commercial and subsistence producers is available to those who qualify. To receive income support, producers must have a historical record of planted crops and must be registered in a directory compiled by the Ministry of Agriculture and Water Resources. This directory lists 3.3 million producers, of which 2.2 million are subsistence farmers and 1.1 million are commercial farmers. Payments to registered producers are allocated on a per hectare basis. Income payments are based on the average area planted and average fixed yields of eligible crops in the three years prior to December 1992. Only land and yields recorded in the directory can be used, so no new land or higher yields can be brought into the program. The minimum and maximum levels of support are established. The maximum upper limit on individually owned land that is eligible for income support is restricted by limits established by the Constitution for land tenure. Direct payment to producers in new pesos per hectare will be gradually phased out. The PROCAMPO per hectare subsidies were fixed in real terms at 1996 levels for the next 15 years. Future PROCAMPO payments can also be used as collateral for loans (USDA 1995).

Corn and dry beans were purchased by CONASUPO, but PROCAMPO promotes a more active role for private agents in trading of corn and dry beans. Upon implementation of PROCAMPO, corn and dry beans were traded at international prices. The marketing of all PROCAMPO crops except corn and dry beans is conducted by private agents.

Rural Alliance

Rural Alliance (Alianza del Campo) is a comprehensive agricultural and rural support program announced by President Zedillo on October 31, 1995. This program commits the government to the continuation of PROCAMPO and outlines the Direct and Productive Assistance to Agriculture Program (PROGRAM) for input and technology subsidies and other technology development programs. This program includes new benefits for livestock producers, government cost sharing of export promotion programs, and decentralization of the administration of CONASUPO to the state level (USDA 1996).

General Agreement on Tariffs and Trade

The Uruguay Round of the GATT negotiations was initiated in 1986, and on April 15, 1994, 111 countries signed the Final Act of the Uruguay Round. The significance of this agreement is the inclusion of agriculture, which played a central role in the Uruguay Round and had not been dealt with in detail in earlier GATT rounds. Agriculture provided more difficulty in the GATT negotiations than did other industries due to the strong government intervention in domestic agricultural markets for most industrialized countries, a situation which dates back to the 1930s. In the Uruguay Round, negotiators recognized that domestic agricultural policies affected border measures and needed to be dealt with. Agricultural policies in the Uruguay Round agreement are built around four areas that distort international trade: market access, internal support, export subsidies, and sanitary and phytosanitary barriers.

Market access addresses policies that directly distort international trade, such as tariffs and quotas. Market access under GATT reduces tariffs and nontariff barriers to trade, which will lower levels of protection in agricultural products. Ordinary custom duties are reduced by 24 percent over a 10-year period in equal installments from the base year of 1986. Nontariff barriers are quantified as tariffs. The advantages of tariffs over nontariff barriers are increased competition among importers, equal application to all importers, transparency, and relative stability. Tariffication is the conversion of quotas, restrictive licensing, variable levies, and other nontariff barriers into ordinary tariffs called tariff equivalents. The tariff equivalent of a product is equal to the difference between the average internal price and average world market price. Tariff equivalents are reduced by 10 percent in equal installments over a 10-year period from the base period of 1986-88.

Tariffs and tariff equivalents are bound. Rates higher than the bound rate cannot be charged without compensating the trading partner. Minimum and current access levels are established for imports subject to tariffication. Minimum access is established if imports during the base period were less than 5 percent of domestic consumption. Current access is established if imports during the base period were greater than 5 percent of domestic consumption. A country under minimum access will provide an access opportunity of 3 percent of the base period consumption in the first year of the agreement, increasing to 5 percent by the completion of the 10-year implementation period. A country under current access must maintain the access opportunity that existed during the base period (USDA 1991).

Internal supports in agricultural policy are quite varied and have numerous effects on production, consumption, and trade. The Uruguay Round recognizes that many trade problems and distortions are caused by domestic policies such as price supports, deficiency payments, input subsidies, marketing and production quotas, and consumption subsidies or taxes. GATT is concerned with internal support polices that affect trade. The Aggregate Measurement of Support (AMS) is used to quantify internal supports that distort trade and will be subject to reduction. The AMS quantifies the effects of market price supports, nonexempt direct payments to producers, and other internal policies. The AMS is based on a 1986-88 base level. The total AMS is capped for the base years and then reduced by 13 percent, beginning in 1995, in equal annual installments for the next 10 years for developing countries. A country is able to obtain credit for commodity support that has been reduced since 1986. This credit applies to most of the grains under study for Mexico.

Export subsidies allow a country to displace more efficient producers, which is one of the most trade-distorting policies. These policies include direct subsides, disposal of stocks below international prices, producer-financed export subsidies, and marketing and transportation subsidies. Both quantity and expenditure are based on a 1986-90 average. The base rates will be reduced in equal annual quantities up to the year 2004.

Research at the Center for Agricultural and Rural Development (CARD) provides a summary of country schedules of commitments under the completed Uruguay Round. This document includes detailed information on intended import, export, and support commitments, specified for the duration of the implementation period on an annual basis (Premakumar et al. 1994).

In Table 3.4, corn, barley, wheat, and dry bean tariffication for Mexico under GATT are listed. The tariff equivalent base rate is calculated by the price gap between the internal and external price and multiplied by the exchange rate to obtain the tariff equivalent base of U.S. $206 per metric ton for corn. GATT tables set 215 percent as the tariff equivalent for corn. The price gap must be reduced in equal annual installments over 10 years. The $206 per metric ton price gap for corn will be reduced by a total

Table 3.4. GATT market access: tariffication and import access for Mexico

Description	Corn	Barley	Wheat	Dry Beans
Internal price (pesos/mt)	42,900	402,890	348,182	899,411
External price (pesos/mt)	13,900	195,470	202,270	410,187
Tariff equivalent base rate ($/mt)	206	160	100	401
Tariff equivalent base rate (percent)	215	128	74	139
Required/applied reduction (percent)	10	10	10	10
Bound rate – year 2004 ($/mt)	185.40	144.00	90.00	360.90
Bound rate – year 2004 (percent)	193.50	115.20	67.00	125.10
Current access (1,000 mt)	8.03	3.54	604.61	5.55
Minimum access				
Base level consumption (1,000 mt)	14,082	497	4887	1,072
In-quota tariff rate (percent)	50	50	50	50
Initial tariff quota (1,000 mt)	2,501	4.74	605	56.50
Final tariff quota year 2004 (1,000 mt)	2,501	4.74	605	56.50

Source: Premakumar et al. 1994.

of $20.60 per metric ton over 10 years, or $2.06 per metric ton per year. In percentages, the price gap of 215 percent would be decreased by exactly 2.15 percentage points each year for the next 10 years.

In Table 3.5, the AMS is presented for corn, soybeans, sorghum, dry beans, barley, and rice. The total market price support is based on the difference between the internal and external price for the commodity and the area that was eligible for production. The base years for these prices are 1986 through 1988. The total price support is a measure of support through guaranteed prices that is added to

Table 3.5. GATT aggregate measures of support for grain crops in Mexico

Description	Corn	Soybeans	Sorghum	Dry Beans	Barley	Rice
Administered price (1,000 $/mt)	834	1,605	662	2,158	855	871
External price (1,000 $/mt)	507	1,248	532	1,681	634	773
Eligible production (1,000 mt)	10,178	588	5,676	988	494	531
Total market price support (billion $)	3,556	255	709	505	117	60
Nonexempt direct payment (billion $)	3,022	512	1,453	1,053	0	335
Global measure of support (billion $)	6,578	766	2,162	1,558	117	395
Credit (billion $)	2,230	462	240	559	56	104
Total AMS (billion $)	8,807	1,228	2,402	2,117	173	499
Required reduction (billion $)	13	13	13	13	13	13
Final outlay - year 2004 (billion $)	7,633	1,065	2,082	1,842	150	432

Source: Premakumar et al. 1994.

nonexempt direct payments to obtain the global measure of support. The total AMS is then obtained by adding the global measure of support and credit given. The total AMS must then be reduced by a total of 13 percent by the year 2004. The commodities with strongest government support are corn and dry beans. The total AMS for beef is 84,478 million pesos, which must be reduced by 13.3 percent by the year 2004. The reduction commitment is an aggregate level across commodities and is not imposed by tariff line items. Therefore, one commodity may have a greater reduction in support to allow for lower reductions in other commodities.

Under GATT, only poultry has tariffication, with a tariff equivalent base rate of U.S. $1,680 per metric ton—a 260 percent difference between the internal and external price. The required reduction is 10 percent to a bound rate in year 2004 of U.S. $1,512 per metric ton, or 234 percent. GATT import access was given only for poultry, with a current access level of 39,600 metric tons and a base consumption level of 706,000 metric tons. The initial access commitment and final 2004 access commitment are 39,600 metric tons.

North American Free Trade Agreement

NAFTA was signed in December 1992, ratified by United States Congress in December 1993, and implemented on January 1, 1994. NAFTA will lead to the establishment of a free trade area between the United States, Mexico, and Canada. The free trade area requires the elimination of all tariff and nontariff barriers to trade between participating countries while maintaining barriers with nonparticipating countries. Among the United States, Mexico, and Canada, most nontariff barriers have been eliminated for agricultural goods and replaced with tariff-rate quotas or an ordinary tariff that will be phased out within 5 to 10 years. Special safeguard provisions will exist for specific products during the first 10 years. Imports are allowed at the preferential tariff rate up to a designated quantity; then, the importing country may apply the tariff at the most-favored-nation rate or the tariff rate at the time NAFTA went into effect, whichever is lower. Country-of-origin rules were established to ensure proper FTA boundaries (USDA 1993).

NAFTA will have different transition periods for different commodities, ranging from immediate elimination to elimination at the end of 15 years. Six basic categories of tariff and quota elimination have been agreed upon in NAFTA, but only four apply to the commodities under study. These four categories are (1) commodities that are already duty free or will have immediate elimination of tariffs, including cattle, beef, and sorghum; (2) commodities under a 10-year transition to eliminate tariffs, including soybean, wheat, rice, and cotton; (3) commodities under a 10-year transition with tariff-rate quotas, including pork, poultry, barley, and malt; and (4) commodities under a 15-year transition with a tariff-rate quota, including corn and dry beans (USDA 1993).

In Tables 3.6 and 3.7, Mexican import polices for the crop and livestock commodities under study are listed for the pre-NAFTA period and under NAFTA. The specific tariff-rate quotas are listed in Table 3.8 for corn, dry beans, barley, pork, and poultry. The tariff-rate quota for corn will remain in effect for 15 years, and up to 2.5 million metric tons will be given duty-free access from the United States. This amount will increase by 3 percent compounded annually over the 15-year transition period. If Mexico imports an amount in excess of the quota from the United States, this excess will be assessed the over-quota tariff of 215 percent, or U.S. $181 per metric ton, for 1994. This tariff will be eliminated by an aggregate 24 percent over the first six years, and the remainder will be phased out over the remaining nine years.

U.S. policies for imports of Mexican agricultural products before NAFTA and under NAFTA are shown in Table 3.9, which lists all the commodities under study. It should be noted that the United States did not import large quantifies of these commodities prior to NAFTA, with the exception of live cattle. Most of the tariffs on these commodities were not very restrictive to trade. Under NAFTA, almost all U.S. trade barriers were eliminated immediately.

Table 3.6. Mexico's trade policy for U.S. grains before NAFTA and with NAFTA

Commodity	Pre-NAFTA Trade Policy	Trade Policy with NAFTA
Corn	Import license required	Tariff-rate quota applied 15-year phase out
Dry beans	Import license required	Tariff-rate quota applied 15-year phase out
Sorghum	15% seasonal tariff	Eliminate immediately
Wheat	Import license required 15% tariff	License eliminate immediately 10-year phase out
Soybeans	15% seasonal tariff	Reduced to 10% immediately 10-year phase out
Soybean meal	15% tariff	10-year phase out
Soybean oil	10% tariff on crude oil 15% tariff on refined oil	10-year phase out
Rice	20% tariff on brown and milled 10% tariff on rough and broken	10-year phase out
Barley and Malt	Import license required 5% tariff	Tariff-rate quota applied 10-year phase out

Sources: USDA 1995, 1996.

Table 3.7. Mexico's trade policy for U.S. livestock and meats before NAFTA and with NAFTA

Commodities	Pre-NAFTA Trade Policy	Trade Policy with NAFTA
Live cattle	15% tariff	Eliminate immediately
Beef	20% tariff on fresh beef 25% tariff on frozen beef	Eliminate immediately
Pork and Slaughter hogs	20% tariff	Special safeguard Tariff-rate quota applied 10-year phase out
Poultry	Import license required 10% tariff	Tariff-rate quota applied 10-year phase out

Sources: USDA 1995, 1996.

Table 3.8. Tariff-rate quota system for imports from the United States

Commodity	Within Tariff-Rate Quota / Over-Quota Tariff
Corn	Duty-free quota of 2.5 million metric tons Quota increases 3% per year compounded annually Initial over-quota tariff of 215% Tariff is reduced 24% in first 6 years and eliminated in 15 years
Dry beans	Duty-free quota of 50,000 metric tons Quota increases 3% per year Initial over-quota duty is 139%, or U.S. $480/ton, with largest duty imposed on imports Duty is reduced 24% in first 6 years and eliminated within 15 years
Barley	Duty-free quota of 120,000 metric tons Quota increases 5% per year Over-quota tariffs of 128% to 175% Tariffs are eliminated over 10 years
Pork	Special safeguard tariff-rate quotas of 120,000 metric tons Within-quota tariff of 20% eliminated over 10 years Quota increases 3% per year Over-quota tariffs of 20% are eliminated over 10 years
Poultry	Duty-free quota of 95,000 tons Quota increases 3% per year Over-quota tariffs of 133% to 260% Eliminated over 10 years

Sources: USDA 1995, 1996.

Table 3.9. U.S. import policy for Mexican products before NAFTA and with NAFTA

Commodity	Trade policy before NAFTA	Trade policy with NAFTA
Corn	Tariff of 0.2 cents per kilogram	Tariff eliminated immediately
Dry beans	Tariff of 1.7 to 3.3 cents per kilogram	Tariff eliminated immediately
Sorghum	Tariff of 0.88 cents per kilogram	Tariff eliminated immediately
Wheat	Tariff of 0.77 cents per kilogram	Tariff eliminated immediately
Soybean meal	3% tariff	Tariff eliminated immediately
Soybean oil	22.5% tariff	Tariff eliminated immediately
Rice	Tariff of 0.69 to 3.3 cents per kilogram	Tariffs phased out over 10 years
Live cattle	Tariff of 2.2 cents per kilogram	Tariff eliminated immediately
Beef	Tariff of 4.4 cents per kilogram	Meat Import Law not applied
Pork processed meat	Tariff of 2.2 cents per kilogram	Tariff eliminated immediately
Poultry	2% to 4% tariff on live poultry	Tariffs eliminated immediately
	4% to 15% tariff on poultry meat	

Sources: USDA 1995, 1996.

CHAPTER 4. LITERATURE REVIEW

Numerous modeling procedures, such as econometrics, computable general equilibrium, linear and nonlinear programming, and social accounting matrix, under partial and full equilibrium, have been used to analyze Mexico's agricultural economic policies. This chapter reviews economic research on Mexico's agricultural economy, focusing on domestic and international trade policy. Past research has focused on a variety of issues: domestic agricultural policy, structural and technological change, land tenure and reform, green revolution and production, labor migrations, and many others. Recent studies have focused on domestic agricultural policy and trade policy issues. A large number of the studies analyze NAFTA policy and liberalization of domestic agricultural policy. The following sections review previous models developed for Mexico.

Early Models and Research

A static linear programming model of Mexico's agricultural sectors, known as CHAC, was one of the earlier Mexican models (Norton and Solis 1983). CHAC was developed by the World Bank in conjunction with the Mexican government to determine the impact of various economic policies. As a tool for policymaking, CHAC is designed to address questions of pricing, trade, input subsidies, and general agricultural policies. The CHAC model is quite detailed, containing 33 crop sectors and their total national supply and utilization, including domestic demand, production, imports, and exports. Each crop has production activities that are differentiated by location and technique. Differentiation results in a total of 2,345 cropping activities that describe alternative production methods. The model is solved by maximizing consumer and producer surplus.

Kehoe and Serra-Puche (1986) develop a static Walrasian general equilibrium model to analyze the effects of government price controls and subsidies on agricultural commodities and food items in Mexico. The study analyzes the welfare effects of alternative policies for reducing the government deficit by cutting subsidies and increasing indirect taxes. A second issue analyzed in the research concerns the effects of producer support on production decisions and the effects of price controls on consumer prices and consumer welfare. The final issue concerns the effects of subsidies and changes in the government deficit on the macro economy.

Results indicate that the effects of agricultural support prices on rural consumer welfare depend upon how responsive supply is to changes in prices. The authors suggest that a more detailed model of the agricultural supply system would improve the study. The functional form may not be appropriate since elasticities are unitary because of the Cobb-Douglas function.

Ballinger and McCalla (1986) develop a multilevel programming model applied to Mexico's agricultural policies. The study analyzes the impact of Mexican pricing policy on Mexican policy goals and tradeoffs among these goals. The impact of changes in U.S. policy affecting Mexico's agricultural sectors and the effect on Mexico's agricultural policy choices are analyzed. The multilevel programming shows the impact of several different pricing policies on four governmental goals and the tradeoffs among these goals. The four policy goals under study are employment, foreign exchange, food grain production, and sector income.

The policy instruments consist of changes in price support, input subsidies, and import prices. Support prices are increased from 10 percent to 40 percent above the market price for corn, wheat, and dry beans. In the second scenario, input subsidies for chemical products are increased by 50 percent to 70 percent above the market price. Finally, some of the U.S. policies that affect Mexico's import price were studied.

This model represents a more realistic framework for the problems that policymakers face by providing a policy tradeoff frontier. The multilevel programming realistically depicts that government policymakers may not have direct control over production decisions. The study reveals the importance of modeling Mexico as a multi-sector, open economy and incorporating both domestic and international multifaceted government policies.

Adelman and Taylor (1991) compare alternative approaches to modeling structural adjustment policies in developing countries using Mexico's food policy as an example. The two models compared are a Social Accounting Matrix (SAM) model and a flexible price Computable General Equilibrium (CGE) model. The policy studied is the redirecting of government investments and subsidies from large-scale to small-scale commercial farmers to raise the productivity of the small-scale farmers. The authors point out that the fixed price SAM model may exaggerate quantity adjustments to policy changes and that CGE models are difficult to calibrate when major economic instabilities exist and assumptions of market clearing may not be realistic.

Aggregate Models

Once NAFTA policy was initiated, a number of economic studies were conducted on Mexico. Both qualitative and empirical models were used. In the following discussion, the results from highly aggregated models are presented first, and then models with greater agricultural detail are analyzed. Most of the highly aggregated models provide results that are often very different or in conflict with results from more detailed models, regardless of model type or type of equilibrium, such as CGE, econometric, or mathematical programming.

Brown (1992) developed an aggregated model with a single sector for agriculture. Brown asserts that the United States is more highly protected than Mexico and that under free trade the United States will import more and decrease U.S. production and employment. These results are contradictory to most other studies.

INFORUM (1990) presents a CGE model that indicates significant gains for U.S. producers based on the assumption of expanding exports to Mexico by 10 percent to 20 percent each year due to the elimination of nontariff barriers. If only tariffs are removed, these gains will not appear.

KPMG Peat Marwick (1991) developed a CGE model with four agricultural sectors: animal products, fruits and vegetables, field crops, and other crops. Under free trade, all production decreased except animal production in the United States.

Josling (1992) points out that the development of free trade areas will have direct and numerous cross-sectoral effects as factors of production shifts to areas that are most profitable in competition in the international market. Agricultural policy programs are quite complex and do not lend to easy aggregation. Results from highly aggregated models can be difficult to interpret and do not account for cross-sectoral implications, which may have contributed to some of the conflicting results in the aggregated models just presented.

Econometric Partial Equilibrium Models

This section discusses econometric partial equilibrium models for research on Mexico's agricultural trade liberalization policies. These models are partial because only the agricultural sector of the economy is modeled. The models cannot answer economy-wide questions, such as resource allocation, changes in wages, migration, and employment. The agricultural sectors are developed in great detail, incorporating a variety of policy instruments for domestic production, consumption, and trade. Partial equilibrium models are usually dynamic, and the adjustment process can be observed over the time of the simulation, and not at a single point in time.

Valdes and Hjort (1993) developed a dynamic, multisector, single-country, econometric-based simulation model. The objective was to analyze the potential impact of NAFTA and alternative liberalization policies on the Mexican wheat, corn, and sorghum sectors.

The model contains highly developed crop and livestock sectors, including aggregate land, vegetables, cattle, beef, hogs, pork, poultry, eggs, fluid milk, wheat, corn, sorghum, barley, cotton, soybeans, soybean meal, and soybean oil. The model includes linkages between crops and the livestock sectors with feed demand equations, cross-commodity effects, and income effects. The macroeconomic sector is exogenous.

Two alternative scenarios are analyzed in comparison to a base scenario. Scenario 1 is the base scenario, which represents the removal of tariffs and quotas as required by NAFTA but leaves domestic policy unchanged. Scenario 2, which represents no NAFTA, includes agricultural liberalization and leaves Mexican subsidies to producers and consumers intact, with a slow downward adjustment in guaranteed prices to producers. Scenario 3 is similar to scenario 2, but domestic policy is liberalized at a faster pace.

The model is simulated to the year 2005. Results for the various scenarios in 2005 are presented in Table 4.1. Production and net imports are expressed in million metric tons, and the percentage change is from the base NAFTA scenario (scenario 1).

Table 4.1. NAFTA and agricultural liberalization scenarios

Commodity	Scenario 1 (base)	Scenario 2	Scenario 3	Scenario 2	Scenario 3
	million metric tons			percent change	
Production					
Wheat	3.89	4.16	3.67	6.90	- 5.80
Corn	17.94	8.42	17.46	-53.10	- 2.70
Sorghum	3.38	3.33	3.42	- 1.50	1.20
Net Imports					
Wheat	1.60	1.53	1.43	- 4.60	- 10.90
Corn	5.19	3.35	5.80	- 35.40	11.80
Sorghum	6.76	6.73	6.46	- 0.50	- 4.50

Source: Valdes and Hjort 1993.

O'Mara and Ingco (1990) developed an econometric model of Mexico's grain and livestock sectors that includes corn, soybeans, sorghum, beef, pork, and poultry. The model is developed in considerable detail, with 33 equations, and estimated using multivariate linear regression, Ordinary Least Squares (OLS), and Two-Stage Least Squares (2SLS). The objective of this model is to analyze macroeconomic and international trade policy effects on the Mexican livestock and grain industries. Trade liberalization is modeled by eliminating guaranteed prices for corn, soybeans, and sorghum and aligning these prices to the world market price. The policy scenario is a counterfactual simulation over the 1974-85 period, and the average percentage results are presented in Table 4.2.

The results indicate that corn was the most heavily protected commodity during the period, with the price decreasing by 17.1 percent. This decrease had the largest effect on production and imports. The sorghum price increased by 15.8 percent, even though the government provides support prices for sorghum. Beef production decreased and the beef price increased. Pork production decreased and the pork price increased. Feed prices should have little impact on beef production because most beef is fed

Table 4.2. Liberalization policies from 1974 to 1985 compared to factual data (percent change)

Variable	Corn	Sorghum	Soybeans	Beef	Pork
Price	- 17.7	15.8	- 3.4	8.0	- 8.1
Production	- 28.4	8.9	- 3.6	- 0.4	0.3
Feed demand	13.5	-1.4	1.5	—	—
Food consumption	3.8	—	—	- 0.6	0.0
Cattle and pig stock	—	—	—	5.7	0.2
Government adjustment	349.3	-30.9	3.8	—	—

Source: O'Mara and Ingco 1990.

grass rather than feed grains. Pork production could increase because of decreased feed costs for corn and soybeans, but sorghum is a major feed component that increases in price.

Hueth, O'Mara, and Just (1993) developed an econometric partial equilibrium model to provide quantitative measures of corn, sorghum, soybeans, wheat, beef, pork, and poultry. Policy instruments are incorporated to allow for lower tariffs, the removal of quotas, strict and transparent rules of origin, and limits to duty drawback. The model is based on the work by O'Mara and Ingco just discussed, which is an econometric model of the macro economy and agricultural sectors.

The policies analyzed in Hueth, O'Mara, and Just are replacements of Mexico's guaranteed prices with exogenous U.S. agricultural border prices for grains, oilseeds, and livestock to simulate various degrees of liberalization. Four scenarios are compared to a base (scenario 1) that does not incorporate NAFTA policy and continues to provide supports and subsidies to Mexican producers and consumers. Under scenario 1, NAFTA policy takes effect without transition in 1994. Scenario 2 is the same as scenario 1, except that Mexican producers continue to receive guaranteed prices for crops. Scenario 3 represents implementation of NAFTA with transitions as specified in the agreement. Scenario 4 is the same as scenario 3, except that Mexican producers continue to receive guaranteed prices for crops. Results indicating the percentage change in production and imports for the 5th year of the simulation are presented for each of the scenarios in Table 4.3.

Scenarios 1 and 3 are the most informative and represent fast liberalization and NAFTA, respectively. Under scenario 1, sorghum production and corn imports are most affected, with 17.7 percent and 106.2 percent increases, respectively. The effect on corn imports is expected, since corn is highly protected by the government at the producer and consumer levels. Under scenario 3, which represents NAFTA, the production and imports most affected are soybean production and corn imports, which decrease by 8.7 percent and increases by 41.6 percent, respectively.

Table 4.3. Production and import change from base in the fifth year (percent)

Commodity		Scenario 1	Scenario 2	Scenario 3	Scenario 4
Beef	production	5.3	5.4	3.7	3.8
	imports	1.5	1.2	-0.4	-0.5
Pork	production	-1.6	-1.6	-0.1	-1.5
	imports	42.6	42.6	21.7	27.7
Poultry	production	3.7	3.8	2.5	2.5
	imports	2.9	2.7	0.6	0.5
Corn	production	-10.6	0.0	-3.6	0.0
	imports	106.2	48.4	41.6	25.2
Wheat	production	-3.3	0.0	-0.3	0.0
	imports	12.0	4.8	0.9	0.1
Soybeans	production	-10.2	0.0	-8.7	0.0
	imports	40.7	31.3	28.5	20.6
Sorghum	production	17.7	0.0	6.8	0.0
	imports	-3.1	21.3	5.9	13.9

Source: Hueth, O'Mara, and Just 1993.

Other studies that can be compared to Hueth, O'Mara, and Just include a CGE study by Robinson et al. (1991), a partial equilibrium multimarket model (PEMM) study by Peterson (1991), Krissoff, Neff, and Sharples (1992), and Rempe (1993). Table 4.4 presents a comparison of these studies.

In analyzing the results presented in Table 4.4, it is important to note that the authors do not all treat corn in the same way for Mexico. For example, Peterson treats corn only as a food grain whereas Robinson et al. and Krissoff, Neff, and Sharples treat corn as both a food grain and a feed grain. The baseline for each of these studies represents a scenario without NAFTA implementation. The results of the different studies for grain production and trade presented in Table 4.4 are for complete trade liberalization. The results from all the studies have the same signs except for sorghum production, which decreases by 25 percent in the Peterson study and increases by 17.8 percent in the Hueth, O'Mara, and Just study. Corn production decreases in all the studies, with the strongest decrease (21.5 percent) in the Peterson study. Corn imports increase in all the studies, with Robinson et al. exhibiting the strongest increase, at 156 percent.

Rempe (1993) developed an econometric partial equilibrium model for Mexico's corn, wheat, and sorghum sectors. Rempe's study estimates area harvested and yield equations for production and demand equations for food and feed. The study analyzes the policies of NAFTA between Mexico and the United States. The baseline assumes the existence of price guarantees for corn and agreement prices for wheat and sorghum. The results are presented in Table 4.5.

Table 4.4. Comparison of studies for trade liberalization in Mexico (percent change)

Commodity		RBHT	KNS	Peterson	Rempe	HOJ
Corn	production	-10.2	-7.3	-21.4	-16.0	-10.6
	imports	156.0	64.0	71.4	86.0	106.2
Wheat	production	—	—	-13.9	-7.0	-3.5
	imports	—	5.0	72.0	2.0	12.6
Soybean	production	—	—	-19.4	—	-10.2
	imports	—	5.0	29.8	—	40.7
Sorghum	production	—	—	-25.5	0.0	17.8
	imports	—	—	82.6	-9.0	3.2
Course Grain	production	—	-10.9	—	—	—
	imports	—	50.1	—	—	—

Sources: (RBHT) Robinson, Burfisher, Hinojosa-Ojeda, and Thierfelder 1991; (KNS) Krissoff, Neff, and Sharples 1992; Peterson 1991; Rempe 1993; (HOJ) Hueth, O'Mara, and Just 1993.

Table 4.5. Differences for NAFTA from baseline projections (percent change)

	Corn		Wheat		Sorghum	
Year averages	Production	Net Trade	Production	Net Trade	Production	Net Trade
1993-1998	-1.5	7.0	-1.5	2.0	-3.0	7.0
1999-2004	-16.0	86.0	-7.0.	2.0	0.0	-9.0
2005-2009	-21.0	86.0	-10.0	2.0	1.0	-19.0

Source: Rempe 1993.

Mathematical Program Partial Equilibrium Models

Krissoff, Neff, and Sharples (1991) developed one of the earlier mathematical models used to analyze the effects of NAFTA between the United States and Mexico (Josling 1992). The model is a multi-country partial equilibrium system with three commodities and individual supply and demand relationships. No results for the three-commodity model are given in Josling.

Liapis, Krissoff, and Neff (1992) present a modeling framework, MEXI, to evaluate the effects of preferential trading arrangements for the agricultural sectors between the United States and Mexico. The Static World Policy Simulation Model (SWOPSIM) framework developed by Roningen (1986) is used to develop the MEXI model, which is a static partial equilibrium net trade model. In the SWOPSIM model, demand and supply functions are specified for specific commodities and countries. Supply and demand are functions of producer and consumer prices, cross-product prices, intermediate demand, and exogenous variables such as income. Trade is the difference between domestic supply and demand. Domestic prices may vary from international prices, depending upon the level of government intervention. World markets clear for a specific commodity when net trade in all countries is equal to zero. The authors point out that an Armington approach is more appropriate for different sources of imports that do not have a single price. The authors do not conduct specific research or policy analysis, but present the model, parameters, data set for the base year of 1988, and all policy instruments used in the model.

The MEXI model has been used by the Economic Research Service at the U.S. Department of Agriculture for a number of trade issues. Results for different trade scenarios from the expanded model of 29 commodities is given in Krissoff, Neff, and Sharples (1992). The scenario used for analyzing a free trade area with Mexico is scenario 1, which represents free bilateral trade between Mexico and the United States with no tariffs or nontariff border restrictions. Under Scenario 2, Mexico removes all border protection on goods from all countries. Scenario 3 combines the assumptions for scenarios 1 and 2. The results for the three different scenarios are presented in Table 4.6.

Grennes and Krissoff (1993) use the SWOPSIM developed by Roningen (1986) and used by the U.S. Department of Agriculture. As mentioned, the model is a partial equilibrium three-region, 29-commodity static model. In the Grennes and Krissoff study, emphasis is placed on specific products in the agricultural sector and Canada is excluded. The Armington method allows products to differ by region. Supply and demand equations are parameterized for 1988 data, which is the base year.

The objective of the study is to analyze the effects of Mexico's trade in agricultural products under NAFTA policy. A number of questions are addressed; for example, what is the effect of NAFTA on the pattern of agricultural exports and imports. Additional trade issues analyzed in the study are how the effects of NAFTA differ from the effects of unilateral liberalization by Mexico, how much trade diversion will occur, and what products will be diverted. The last issue addressed is how macroeconomic changes, such as income and exchange rates, would affect the agricultural sectors.

The model is based on 1988 conditions for a U.S.-Mexico NAFTA scenario and removes all tariffs and the tariff equivalent of licenses and quotas that were in place in 1988. It is important to note that all domestic policies are left in place. A second scenario evaluates unilateral free trade by Mexico. Results for the scenarios after five years of adjustment are shown in Table 4.7.

General Equilibrium Models

The study by Robinson et al. (1991) focuses on three modeling issues in a computable general equilibrium model. The first issue is the explicit modeling of agricultural policies and linkages. The second issue is labor migration. The third issue is import demand specification, with a comparison of Armington and AIDS models. Incorporated into the model are Mexico's agricultural policies, which are tariffs; import quotas for beans, corn, and other grains; input subsidies to producers and processors; and

Table 4.6. Policy scenario for trade liberalization (million U.S. $)

Activity	Mexico 1	Mexico 2	Mexico 3	United States 1	United States 2	United States 3
Agricultural exports to U.S./ Mexico	166	25	160	480	435	438
Agricultural imports	443	465	469	169	41	160
Producer welfare	-438	-503	-457	225	279	222
Consumer welfare	978	1,068	1,035	-122	-232	-126
Government cost	-440	-500	-462	207	201	199
Exports						
Grains and oilseeds	11	—	—	369	—	—
Livestock, meats, and dairy	56	—	—	49	—	—
Producer welfare						
Grains and oilseeds	- 392	—	—	338	—	—
Livestock, meats, and dairy	1,472	—	—	-88	—	—
Consumer welfare						
Grains and oilseeds	835	—	—	-260	—	—
Livestock, meats, and dairy	-1,345	—	—	72	—	—
Government cost						
Grains and oilseeds	27	—	—	-279	—	—
Livestock, meats, and dairy	87	—	—	17	—	—

Source: Krissoff, Neff, and Sharples 1992.

Table 4.7. NAFTA policy scenario results (percent change)

Commodity	Production	Consumption	Price
Mexico's domestic commodities			
Corn	-7.3	-7.3	-15.9
Other coarse grain	-10.9	13.9	-15.8
Cattle	0.2	-0.5	-15.7
Beef	-0.2	-0.2	- 0.3
Pork	-0.5	0.5	-1.1
Poultry meat	2.1	2.1	3
Poultry eggs	2.5	2.5	-9.3
Mexico's consumption of U.S. commodities			
U.S. Corn	—	64.0	-33.2
U.S. Other coarse grain	—	50.1	-32.3
U.S. Cattle	—	11.2	-7.4
U.S. Beef	—	15.0	-5.0
U.S. Pork	—	25.3	-8.1
U.S. Poultry meat	—	23.9	-9.1
U.S. Poultry eggs	—	4.8	0.0

Source: Grennes and Krissoff 1993.

a tortilla subsidy to low-income consumers. Tariff equivalents of quotas are determined endogenously, and are not as fixed ad valorem wedges. U.S. policy includes deficiency payments and Export Enhancement Program (EEP) payments. The model is able to analyze fiscal impacts on the government from changes in agricultural policies and production.

The model is a CGE, which includes the United States, Mexico, and Canada and 11 sectors, of which 4 are agricultural. Six Mexican policies are modeled: input subsidies in the agricultural sector, tariffs and quotas, direct subsidies in the food processing sector, price subsidies, and a low-income tortilla subsidy.

Six scenarios are analyzed. Scenario 1 is industrial trade liberalization, scenario 2 is agricultural trade liberalization, and scenario 3 is agricultural trade liberalization and domestic agricultural liberalization for Mexico. Scenario 3 includes the removal of corn input subsidies. Scenario 4 is trade liberalization and common agricultural policies among countries, scenario 5 is partial trade liberalization, and scenario 6 is partial trade liberalization and capital growth in Mexico. The base represents the absence of trade liberalization. Results for trade liberalization under scenarios 2 and 3 are presented in Table 4.8.

Table 4.8. Percent change from the base for scenarios 2 and 3

	Scenario 2		Scenario 3	
Commodity	Production	Exports	Production	Exports
U.S. corn	4.1	156.0	5.1	185.0
U.S. program crops	0.8	40.5	1.7	88.2
Mexican corn	-10.2	0.0	-19.4	0.0
Mexican program crops	-7.1	0.0	-21.1	0.0

Source: Robinson et al. 1991.

Migration from rural to urban areas in Mexico under scenarios 2 and 3 is 290,000 people and 773,000 people, respectively. Migration from Mexico to the United States is 238,000 people and 610,000 people, respectively, under the two scenarios.

A second CGE model by Levy and van Wijnbergen (1991) and its results are presented in Josling (1992). Their objective was to model the degree of liberalization in the maize market. The model incorporates five rural good sectors, two urban sectors, seven factors for production, and six types of households. The results from this research are reported as efficiency gains and indicate severe initial adjustments to a drop in the maize price to rural households. Land price declines by 25 percent, and labor migration to the cities is about 700,000 people. In this model, if the United States would remove its 5 percent tariff on fruit and vegetable imports, labor migration would decrease by 200,000 people.

The results may indicate that producers of irrigated land are making substitutions among corn, vegetables, and fruit. The results also indicate that land distribution and labor markets play an important role in the distributional impact of trade liberalization in corn. Corn trade liberalization would lower demand for labor in this sector, but the fruit and vegetable industries are more labor intensive, so U.S. elimination of these tariffs would benefit labor as indicted by the reduction in migration.

Levy and van Wijnbergen (1992) present research for corn liberalization policies and a NAFTA policy scenario using the CGE model just discussed. The model includes two types of land: irrigated and rain-fed. The first scenario represents the removal of all corn price distortions, which reduces prices to producers and rural consumers by about 33 percent and raises the price to urban consumers by about 50 percent. Corn production decreases by 25 percent on rain-fed land and by 50 percent on irrigated land. Irrigation farmers are able to substitute corn production for other crops such as vegetables or fruits. Although production decreases, corn imports decrease because urban consumers must now pay a higher price.

The second scenario represents implementation of NAFTA policy. Mexican tariffs on other grains and U.S. barriers are removed. Migration is smaller than in the previous scenario. The results are similar to the previously mentioned corn liberalization policy, but the effects are not as strong.

Livestock Models

A comparison of the studies by Hueth, O'Mara, and Just and Krissoff, Neff, and Sharples for livestock production and trade is presented in Table 4.9. The results are different between the studies. Beef production decreases by -0.02 percent in Krissoff, Neff, and Sharples and increases by 5.3 percent in Hueth, O'Mara, and Just. Hueth, O'Mara, and Just note that this difference may be because their study used more recent data and the recent data reflect greater price responsiveness in the commodities. The results in Hueth, O'Mara, and Just are similar to other CGE results, but not the same as all the econometric results. A major conclusion for the difference in results is that the studies use different specification for the model, as opposed to attributing the differences to a general or partial equilibrium framework (Hueth, O'Mara, and Just 1993). This lends credibility to the idea that model specification and detail is of greater importance than the type of modeling procedure used. The highly aggregated models definitely provided unacceptable results, regardless of model type.

Table 4.9. Comparison of trade liberalization for livestock industries

	Krissoff, Neff, and Sharples		Hueth, O'Mara, and Just	
Commodity	Production	Imports	Production	Imports
Beef	-0.2	15.0	5.3	1.5
Pork	0.5	25.3	-1.6	42.6
Poultry	2.1	23.9	3.7	2.9

Sources: Krissoff, Neff, and Sharples 1992; Hueth, O'Mara, and Just 1993.

Hahn (1993) developed a static nonlinear programming model that can be used for North American trade in animal products under different policy scenarios. The model's objective is to minimize production and trade costs, subject to constraints such as consumer demand. The model can analyze dairy, poultry, and beef policies in Canada, the United States, and Mexico. The complete model and program are presented; however, no results are provided.

Melton and Huffman (1993) analyze the impact of NAFTA policy on beef industries in the United States and Mexico. The study's objective is to focus on beef supply in Mexico and incorporate technology transfer, such as beef packing plants. The authors assert that, in the long term, the transfer of technology is key to beef trade and the distribution of benefits.

The model consists of a static partial equilibrium econometric model. The supply in the beef industry is divided into three interlinked sectors: cow-calf, stocker-feeder, and meat packing. Demand consists of beef and hides at the national aggregate level. A cost function for the packing industry is derived. It is important to note that the U.S. price of feed grains is fixed in simulations.

The study presents three scenarios. Scenario 1 is a short-run post-NAFTA scenario that eliminates all beef tariffs and trade restrictions in both countries. Because there is not enough time to allow for structural change, technology does not change and there are no investments, but the beef herd increases by 5 percent. Scenario 2 represents the long term. Liberalization effects allow changes in technology in Mexico's beef industry, which allows packing plants to enter Mexico. Scenario 3 is also a long-run scenario that includes a 20 percent increase in wage rate and a 10 percent increase in per capita income.

The results for scenario 1 indicate that, in the short run, Mexico will increase feeder cattle exports to about 3.2 million head. Relative to 1980-82, this is an increase of 400 percent, or about 225 percent higher than current levels. The increased exports will increase the U.S. feeder calf supply by about 10 percent and depress prices by about 32 percent. Mexico will increase beef imports by 2.4 billion pounds, or about 10 times current levels. Mexico will increase imports of feed grains by 155 million bushels, which is more than double current levels on a corn equivalent basis. The authors estimate that the United States could provide one-half of Mexico's total beef demand of about 30 pounds per capita.

In scenario 2, technology transfer occurs over the long run and Mexico develops modern packing plants. The Mexican beef cow herd doubles from 8.4 million head to 16.4 million head; the U.S. beef cow herd decreases by 13 percent, and Mexican feeder cattle exports are 1.4 million head greater than pre-NAFTA levels but 18.0 million head less than under the short-term post-NAFTA scenario. Mexico goes to low-cost post-weaning technology, and the country exports an additional 2.5 billion pounds of retail beef to the United States. U.S. feed grain exports to Mexico increase by about 170 million bushels relative to pre-NAFTA levels, and the consumer beef price in Mexico is U.S. $0.30 to $0.35 per pound less than the pre-NAFTA level.

The results from scenario 3 indicate a 10 percent increase in real wages and income and a small increase in beef demand. Because the wage rate increase reduces Mexico's comparative advantage in beef plant costs, Mexico exports a larger number of feeder cattle (1.8 million head versus 1.4 million head), less retail beef is exported (1.9 billion pounds versus 2.5 billion pounds), and U.S. feed grains are unchanged.

Peel (1996) discusses a study that analyzed the effects of Mexican cattle exports to the United States on the price of U.S. feeder cattle. The study is based on statistical estimates of a system of price equations for three weight groups of steers—300 to 400 pounds, 400 to 500 pounds, and 500 to 600 pounds—over the period 1973-90 (Cockerham 1995). The monthly U.S. average steer price is a function of fed cattle prices and input prices, such as feed, Mexican cattle imports, and seasonal variables. The research indicates that Mexican cattle imports had the greatest impact on the U.S. price of 400- to 500-pound steers—an average of U.S. $1.98 per head, or $0.44/cwt.

Garcia-Vega and Williams (1996) developed a linear econometric model for Mexico's livestock sectors for cattle, hogs, and poultry and for the feed sectors for sorghum, soybeans, and corn. Livestock inventories are treated as capital within a Jarvis (1974) framework, so producers are portfolio managers. Different meat demand systems were tried, including the Rotterdam system, Almost Ideal Demand System, and a linear single-equation system. The Rotterdam system and AIDS did not converge to equilibrium in simulations when they were integrated with the full Mexico model, even though the demand systems did converge alone.

The model baseline represents a no-liberalization policy, and five different policy simulations are analyzed: (1) only Mexican cattle exports are liberalized, (2) only Mexican cattle imports are liberalized, (3) only Mexican beef imports are liberalized, (4) only Mexican feed imports are liberalized, and (5) full liberalization of Mexican cattle, beef, and feed imports and cattle exports.

The results for scenario 5 are presented with full liberalization occurring during the 1986-91 period. These results indicate that unilateral liberalization benefits both the cattle and feed sectors in Mexico. Cattle prices increased on average by 50 percent. This increase led to a 2.2 percent increase in Mexican feed production and increased consumption of corn, sorghum, and soybean meal. The feed price decreased by an annual average of 21.7 percent over the period. In general, the results indicate that liberalization policies will substantially impact Mexico's livestock sectors.

CHAPTER 5. THEORY AND CONCEPTUAL MODEL

This chapter consists of two general sections. The first section presents a literature review of agricultural trade models and the development and justification of the research methods and theory used to analyze the research problem. The second section discusses Mexico's agricultural policy and appropriate modeling techniques. Charts are presented that depict the different agricultural models developed for the policy analysis. The models are also presented in general functional forms.

Agricultural Models

An econometric estimation of applying statistics to microeconomic theory was applied to agricultural commodities in the 1940s and the 1950s, including work by Wold and Jureen (1943), Meinken (1955), and Nerlove (1956). One of the earliest commodities models developed was by Fox (1953). Earlier work consisted of either supply or demand for a single commodity, such as corn in the United States by Houck and Ryan (1972) and Morzuch, Weaver, and Helmberger (1980); beef and pork in France by Mahe (1979); and rice in Japan by Otsuka and Hayami (1985). The analysis of these single-commodity models has been improved by access to data, new specifications, and estimation.

Many multimarket models have been developed to provide an applied production analysis of the interactions of several products. These models are not based on rigorous microeconomic theory, since the properties of supply and demand are not satisfied, but the specifications satisfy the behavior of producers and their intuitive understanding of the market. A few examples of multimarket models of the U.S. agricultural and livestock industries include Arzac and Wilkinson (1979), Gadson, Price, and Salathe (1982), and Westcott and Hull (1985).

Supply dynamics is quite important in agricultural supply models because producers base current production decisions on the expected future price. There are many ways to incorporate pricing decisions in a model. The most simple is naive price expectations, where the expected future price will be the same as the last period's price. However, this method seems unrealistic because no information is used by producers except the last period price. The adaptive expectations model developed by Cagen (1956) incorporates error in expectations of previous price levels. This method provides a declining geometric distributed lag form for expected prices as a function of all past prices, where the most recent price has the greatest weight. Nerlove (1956) expanded the adaptive expectations model so that the same reduced form is provided, but it will not induce additional serial correlation in the disturbance if there were none to start with. The rational expectations model was first developed by Muth (1961) and has been used extensively in a number of agricultural models.

Demand Systems

Along with the development of econometric commodity models has been the development of demand systems. One of the most noted early works on demand was by Shultz (1938), which contains theoretical discussions but also includes studies of demand for U.S. agricultural products such as sugar, wheat, and cotton. Stone (1954b) improved demand estimation by imposing theoretical properties of homogeneity of degree zero on a double-logarithmic demand function. Stone (1954a) was able to improve his previous demand estimation by imposing all theoretical properties of a demand system in the Linear Expenditure System. The theoretical restrictions imposed by Stone (1954b) are homogeneity, adding up, symmetry, and negativity of the direct substitution effect. The linearity of the model does impose some undesirable effects; for example, inferior goods would violate concavity and result in positive price elasticity, and no two goods can be complements; otherwise, concavity will not hold.

An improvement upon Stone's (1954b) first (double-log) model is the Rotterdam model by Theil (1965). The model improves on Stone's model by imposing theoretical restrictions through the restrictions of the parameters. The model also allows a substitution matrix to be estimated with only symmetry imposed, thus allowing substitutes and complements to be identified directly from estimation results. Homogeneity is consistently rejected in the Rotterdam model.

Duality was used by Diewert (1971) in obtaining flexible functional forms. Christensen, Jorgenson, and Lau (1975) obtained demand functions from an indirect translog model. The Almost Ideal Demand System (AIDS) is developed by obtaining the budget shares from a semi-logarithmic model which is extended by adding a quadratic form to allow for interaction between prices (Deaton and Muellbauer 1980). This system is derived from utility maximization and is easier to estimate than the previously mentioned demand systems, and it can be used to test for homogeneity and symmetry through restrictions on the parameters. Many of these demand systems have been used in modeling international agricultural policy and obtain parameter elasticities that can be used in analysis. Examples of this systems include Hassan and Johnson (1984), McKenzie and Thomas (1984), Chalfant (1987), Wahl (1989), and Hayes, Wahl, and Williams (1990).

In demand theory, there are a number of properties that one would like to hold or be able to impose on the demand system. Marshallian and Hicksian demand are derived from utility maximization subject to a budget constraint and budget minimization subject to a utility constraint. From the maximization of the utility function subject to a budget constraint, a Marshallian demand function is derived. The

Marshallian demand is a function of income, own price, and substitute or complement goods. The Hicksian demand is a function of prices and the maximum obtainable level of satisfaction.

Properties of Marshallian demand functions are adding up and homogeneity. Adding up is satisfied because of the equality of the budget constraint, and homogenous of degree zero is imposed by the budget constraint that is linear and homogenous in income and prices. The properties of Hicksian demand functions are adding up, homogeneity, symmetry, and negativity. Adding up is imposed by the budget constraint, which states that the total value of Hicksian demands is equal to the total expenditure. The Hicksian demands are homogenous of degree zero in prices because the expenditure function is homogenous of degree one (Deaton and Muellbauer 1980).

Price Expectations and Supply Response

Production decisions are based on the expected profitability at the time of harvest or selling of commodities. The greatest uncertainty for producers, aside from weather, is the price received at harvest. Price at the time of sale is uncertain, so producers must make production decisions based on expected future market prices. If producers expect prices to be favorable, then greater production will occur. Producer formulation of price expectations has received much attention from economists because of its large impact on production decisions.

The most simple price expectations model is the naive price expectations model, which is simply that this year's expected price, P_t^e, is the same as last year's price, P_{t-1}, and written as $P_t^e = P_{t-1}$. Producers do not incorporate any additional information aside from last year's price, which is not a very realistic assumption. This type of price expectation fails to capture any price dynamics within the industry.

Price expectations can also be revised based on the error associated with the previous level of price expectation, which is called adaptive price expectations and was first proposed by Cagan (1956). The adaptive price expectation model can be written in a geometrically declining distributed lag form for expected prices as a function of all past prices.

Duality Theory

Agricultural economists have been concerned with the theoretical underpinnings of their models and have tried to solve these theoretical properties in supply and demand systems. Econometric applications using duality theory in estimating production and input demand systems estimation have been conducted by Lau and Yotopoulos (1972); Yotopoulos (1976); and Sidhu and Baanante (1981). Duality theory has made research less difficult in other issues, such as technical change, output bias, and returns to scale. Duality simplifies the derivation of output supply and input demand relationships from the profit function by simple differentiation. Also, the aggregate input use is sufficient for estimation. A number of studies have used duality and, recently, duality has become quite popular among agricultural economists. These studies include Antle and Aitah (1986), Shumway (1983), and Huffman and Evenson (1989).

Input Markets and Jointness

Agricultural production is dependent upon the input market for such factors as labor, energy, fertilizer, mechanization, credit, and irrigation facilities. Agricultural economists have recognized the importance of these markets as part of the general economy and their interaction with production. A number of studies have been conducted dealing with these issues, such as Fox and Norcross (1952), Roop and Zeitner (1977), Chambers and Just (1982), and Adelman and Robinson (1986). Jointness of agricultural technology and measures of output supply and input demand have also been closely studied (Weaver 1983; Shumway 1983; Ball 1988). This type of research is important to policymakers because it provides information on output relationships and input-output linkages that can be used in formulating public policy.

Computable General Equilibrium Models and Partial Econometric Models

Winters and Munk provide a good analysis of the strengths and weakness of CGE and partial equilibrium models in Goldin and Knudsen (1990). The CGE has some limitations, such as the derivation of parameters. Parameters are not estimated from time-series data; therefore, the results are based on the choice of parameters and only indicate potential effects. Many studies using CGE models are made in comparative static frameworks, which are not relevant for measuring short-term benefits with long-term costs. Also, government polices are often treated as price wedges, and aggregation of consumption and products, which are very different in production, is aggregated.

Partial equilibrium models of agriculture can provide great detail about the industry and interactions within the industry, but these also fail to provide linkages to the rest of the economy that may be critical. Although agriculture may affect other economic sectors, it may not be important to account for these effects because the critical factor, when analyzing only the agricultural sector, is the strength of the second round of feedbacks to the agricultural sector from the general economy. Prior to model development, the strength of feedbacks are difficult to determine; thus, large leakages may occur in partial equilibrium models with little indication to the policy modelers.

In the past decade, computable general equilibrium models have become quite popular in carrying out policy analysis (Harris and Cox 1984; Tyres 1985; Adelman and Robinson 1986; Parikh 1988; Robinson 1990; and Burniaux et al. 1990). Some studies have indicated significant differences between results from computable general equilibrium models and partial equilibrium models, including de Janvry and Sadoulet (1987). There can also be large differences among CGE models when the degree of aggregation is large among them. This situation was indicated by the review of CGE models for Mexico. Therefore, the detail of CGE models is critical for accurate results. Hertal (1989) surveys some of these issues, including aggregation, specification, and modeling of policies, for CGE models in agriculture.

Agricultural Trade Models

Early commodity models focused mainly on a closed economy, and if there was an international sector, imports and exports were treated as exogenous and added to supply or demand by identities (Cromarty 1959; Egbert 1969). The reason for closed economy models was not the inability of economists to model trade but that during the 1950s and 1960s agricultural trade was quite small and not of major importance. The commodities traded, such as tropical products, generally had little domestic competition. Trade barriers that prohibited liberalization of agricultural trade among countries was not an important issue during this period.

During the 1970s, world agricultural trade became quite important, with agricultural exports increasing by more than 200 percent in the world. A decline in world production caused the United States to double its exports during this period. Agricultural trade modeling increased during the 1970s, which was a reflection of reality as the U.S. government and the private market became more concerned with agricultural trade and a number of international economic issues.

Two-Region Models

The earliest agricultural trade models were simple two-region models in which the world is divided into two parts: the country of interest and the rest of world (ROW). Import demand, export supply relations, and linkages between domestic and international price were developed. This type of model provides net trade results for the country under study and the ROW but does not account for destination of exports or region of imports. In these models, two approaches are normally used to obtain parameters. The first is to estimate them directly, and the second is to calculate them by means of Yntema's (1932) formula. Thompson (1981) points out that there is a lack of consensus on estimated parameters and elasticities for these trade models. There are four main reasons for this discrepancy.

First, excess demand and supply equations for the ROW are highly aggregated. If countries participating in trade change policies, volume, or trade partners, their elasticities may also change, so estimation results are quite sensitive to the time period used for estimation. Second, numerous factors affect trade and elasticities, including exchange rates, tariffs, subsidies, and transportation costs, but once again we are dealing with highly aggregated data that do not take these into account. Third, most two-region models were developed for single commodities and did not take into account important linkages and interrelationships among different commodities. Finally, the models do not account for variables that shift demand and supply in other countries.

Multiple-Region Models

The multiple-region model of agricultural trade does not treat any region or country as dominant in determining world trade; instead, trade depends upon the interrelationships among regions or countries. Normally, all regions are assumed to exhibit some market influence and affect world price and trade to some degree for their region. Multiple-region models have three classes of trade models: nonspatial price equilibrium, spatial price equilibrium, and trade flow and market share models. These models differ in price linkages, trade source determination, and restrictions on behavior of variables in the model.

Nonspatial price equilibrium models have a world market price that is determined by supply and demand in all regions. These models do not provide information on source of trade, accounting only for net trade by region or country. Nonspatial models have three types of price linkages. The first is a global market-clearing price for all world transactions. The second is prices linked through transportation cost, except for one region or country that has its price linked to other regions. The third type links prices through transportation costs pairwise along established trade flows (Thompson 1981). Nonspatial price equilibrium models have been quite popular among applied economists because these models are often easier to use and cost less to solve (Thompson and Abbot 1982).

Utilizing nonspatial price equilibrium in agricultural trade has become quite popular in CGE models over the last decade. One of the larger models, the Basic Linked System (BLS), was developed in Austria. The model has been used to analyze agricultural trade liberalization in developing countries by Parikh et al. (1988) and Frohberg, Fischer, and Parikh (1990). A number of CGE models have been built to analyze agriculture and trade in great detail. A number of studies using both single and multiple countries are presented by Goldin and Knudsen (1990).

Spatial equilibrium models have been common in agricultural trade. These models are able to provide information on trade flows and trade destination by incorporating endogenized trade flows and market shares. The prices are linked to countries that are trading partners. Developers of early spatial equilibrium models include Schmitz (1968) and Takayama and Liu (1975).

The development of trade flow and market share models was partially due to the inadequacies of spatial trade models to accurately account for trade flows and lack of empirical support for the law of one price. The trade flow and market share models focus on the trade matrix, which includes various approaches to transform the trade flow matrix from one year to the next. This is accomplished without using prices. Two approaches are mentioned by Thompson (1981): explaining the trade matrix with econometric models and using an Armington-type approach in which elasticities of substitution are less than infinity for the importing regions.

Armington Model

One would expect commodities to have variation based on point of origin, which is recognized among agricultural traders. In international trade, a commodity may have quality and characteristic differences. One country may be a more reliable trade partner, the political agenda of a country may favor trade with specific countries, or discounted prices may be offered. Agricultural trade models developed to account for product differentiation by country of origin often use Armington (1969) models. This approach depends upon the consumer's utility being homothetic and weakly separable, so that the decision process occurs in two stages. The first stage is allocation of expenditure to particular commodities, and the second stage is the allocation of expenditure to different sources of imported commodities, which is based upon the constant elasticity of substitution (CES) function. Armington allows calculation of cross-price elasticities between imports from all origins using estimates of the aggregate price elasticity of demand for imports. Numerous studies have used Armington's approach for agricultural trade (Abbot and Paarlberg 1986; Figueroa and Webb 1986; Babula 1987; Ito, Chen, and Peterson 1990).

The Armington trade model has some drawbacks and has been criticized for imposing homotheticity and separability on the utility function and using a CES functional form. Alston et al. (1990) point out that trade patterns change only with relative price changes and that elasticities of substitution between all pairs of products are identical and constant because of the assumptions imposed on the model. Other researchers have shown the assumptions of Armington to be too restrictive and unreasonable (Winters 1984). Some research has supported use of AIDS as opposed to the Armington approach (Davis and Kruse 1993).

Disequilibrium Models

Production and consumption do not always have an equilibrium because markets may function under policies of price and or quantity control. Under these conditions, the short side of the market would determine the demand or supply. For example, a price guarantee to producers above equilibrium would create excess supply, so quantity transacted would be determined by demand, assuming excess supply cannot enter the market. Quantity supplied can determine the quantity transacted when prices are maintained below equilibrium conditions, such as a fixed price for consumers. Therefore, excess demand exists. Many agricultural markets operate under conditions of disequilibrium, and previous research of these markets usually focuses on estimation of welfare losses and transfers due to regulations. Oczkowski (1993) provides a thorough review of disequilibrium econometrics and applications to agriculture.

Conceptual Model for Mexico

The model developed for Mexico is a nonspatial multimarket dynamic partial equilibrium econometric simulation model. Domestic and international agricultural policy instruments for PROCAMPO, NAFTA, and GATT are incorporated into the model. A nonspatial model can be justified because most agricultural imports are from the United States. Since the early 1980s, Mexico has been a net importer of all the commodities under study except light-weight cattle, which are exported to United States. Use of a partial equilibrium model as opposed to a general equilibrium model such as CGE has been justified for analyzing the effects of NAFTA on Mexico's agriculture in the literature review. The major difference in results from partial equilibrium and general equilibrium models is due to the detail of specification in the agricultural sectors and incorporation of policy instruments (Hueth, O'Mara, and Just 1993). Mexico is not a large importer on the world market and is assumed to have no impact on world prices. Therefore, Mexico is assumed to be a small country and price taker in international trade.

The model consists of seven agricultural sectors and three livestock sectors. The crop commodities modeled are corn, dry beans, wheat, rice, barley, sorghum, and soybeans. The livestock commodities are beef, pork, and chicken.

In markets with little government intervention, equilibrium or market clearing of supply and demand is achieved through the pricing system. In Mexico, the government has intervened in the market in numerous ways: guaranteed prices, support programs for agricultural commodities, input subsidies, import license controls, tariffs, marketing and processing subsidies, and direct consumption subsidies. These policies have separated the production and consumption sectors, and the price linkage does not facilitate equilibrium. Equilibrium in Mexico's agricultural market is achieved through controlled trade by the government. Producers have received input subsidies and guaranteed prices above the international price. Marketing subsidies are passed on to consumers through processors. The difference between production and consumption is used to determine the quantity of imports needed to close the market, and the Mexican government uses quota restrictions to achieve this.

Figure 5.1 presents the basic polices for Mexico and the effects on production, consumption, and trade at the farm level, at the off-farm domestic level, and in the international market. At the farm level, producers receive the government guaranteed price, Pg, for their crops and produce at Qfp. In Mexico, on-farm consumption is quite prevalent, which is indicated by Qfc, and the guaranteed price is the opportunity cost for not selling the product in the domestic market. Many farm families don't have access to subsidized corn tortillas because these have been targeted toward the urban poor. The difference between Qfp - Qfc is the amount marketed in the domestic market, Qp. About 40 percent of corn production is consumed on farms.

The domestic market sections shows the amount of production, Qp, provided by farmers at the government guaranteed price, Pg, for sale on the domestic market. The guaranteed price is higher than the supply and demand equilibrium, which normally would create excess supply. But, the Mexican government subsidizes consumers directly and through processors as indicated by the lower price, Pcs. Therefore, excess demand is normal for major staples in Mexico such as corn, dry beans, and wheat. Domestic consumption is at Qc with a price of Pcs, which indicates retail price with subsidies. At these prices, imports of Qc - Qp are required to satisfy excess demand.

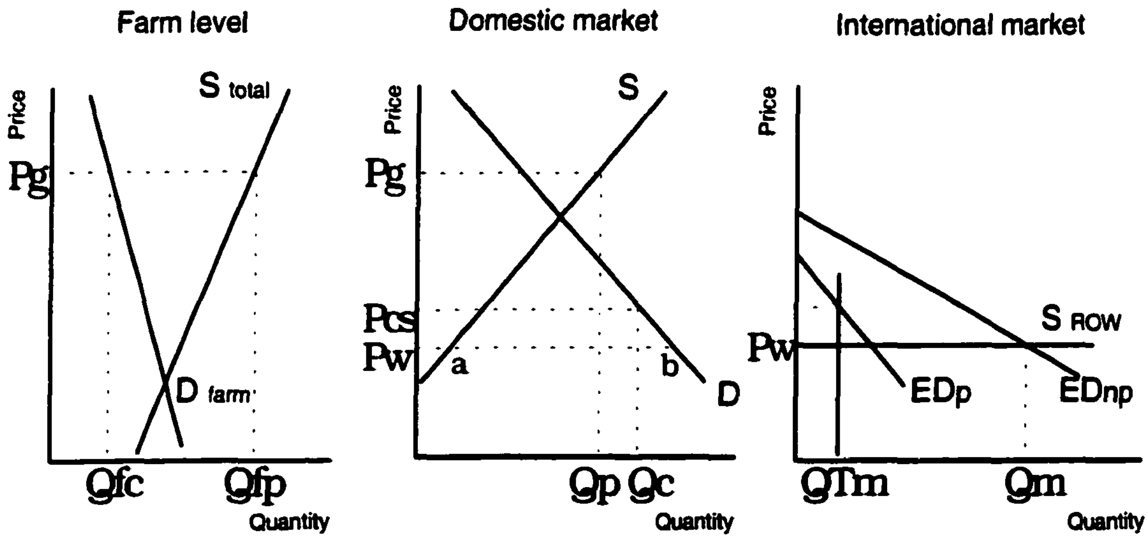

Figure 5.1. Farm production, consumption, and trade under import quotas

The international price, Pw, is lower than the government guaranteed price. The government must control imports through quotas or variable levies to maintain these guaranteed prices. For example, the government issues import licenses for corn to be imported at the world price, Pw, assuming a perfectly elastic world supply of corn. Under producer guaranteed prices and subsidized consumer prices, the excess demand curve is EDp and the import quota is QTm. Under market equilibrium without government intervention, the import excess demand curve would be EDnp and imports would be Qm at the world price, Pw, which is the distance a – b in the domestic market.

These figures indicate that production and consumption are not linked through a market or pricing mechanization to solve for equilibrium. The production and consumption sectors are modeled independently, based on the government prices, with trade accounting for the difference between production and consumption. Prices are not solved within the sysem but are exogenous as determined by the Mexican government and, under the new policy, by the international market.

Under NAFTA, the policy instruments utilized are tariffs and tariff-rate quotas, which are gradually eliminated over 10 to 15 years. Tariff-rate quotas are established for corn, dry beans, and barley. For corn, NAFTA established a tariff-rate quota that allows imports of up to 2.5 million metric tons duty free, above which imports have a tariff of 215 percent. The tariff is reduced over a 15-year period. The quota expands by 3 percent annually over a 15-year transition period, after which no trade barriers will exist.

Figure 5.2 presents a tariff-rate quota utilized by Mexico under NAFTA. In Figure 5.2 (A), imports are less than the quota imposed under the tariff-rate quota. Imports up to the quota level, as indicated by the vertical line Quota, will be duty free. Corn will be purchased at the world price, Pw, which is the world excess supply. In Figure 5.2 (B), imports, Qm, are greater than the tariff-rate quota; therefore, corn imports will be assessed a 215 percent ad valorem tariff, as indicated by excess demand, with the tariff, ED tariff, which starts at the quota level. The price importers must pay is Pt = Pw*(1 + 2.15) if Qm > quota. If no tariff is applied, imports would be where ED intersects ES, the excess supply curve.

In Figure 5.3, imports exactly equal the quota, Qm = Quota, in which case importers would purchase at the world price, Pw. The excess demand, ED, curves are different in cases (A) and (B). In (B), excess demand is greater but imports are still equal to the quota. If excess demand is large enough so that the tariff line, ED tariff, starts at a point above the world price on the quota line (for example, point a), Mexico would import at the higher tariff rate.

GATT is more comprehensive than NAFTA because it addresses market access, internal support, export subsidies, and sanitary and phytosanitary issues. Tariff and nontariff barriers are converted to

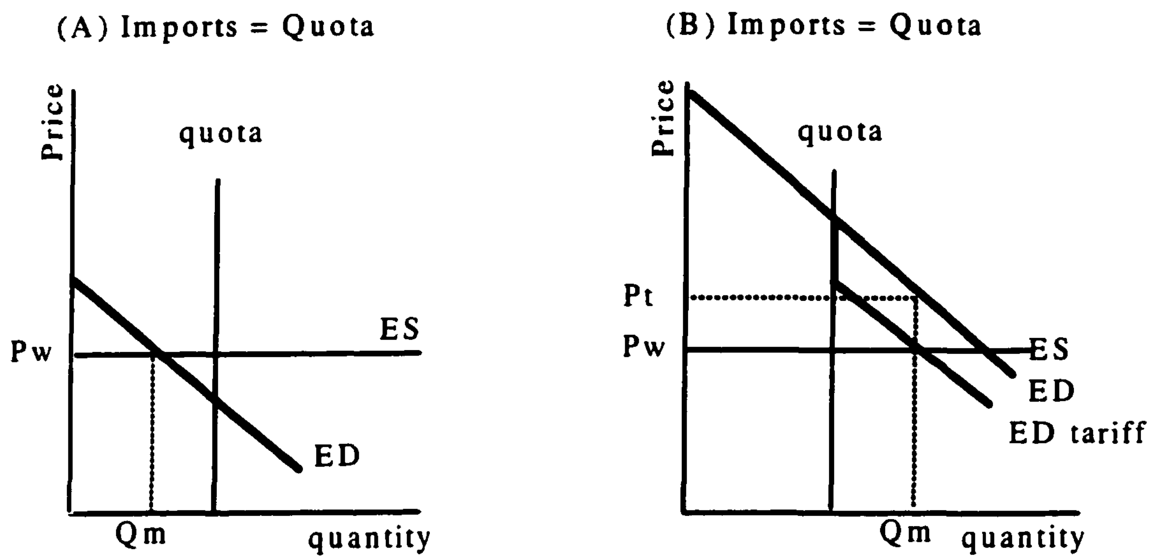

Figure 5.2. NAFTA policy for corn with tariff-rate quota at various levels of imports

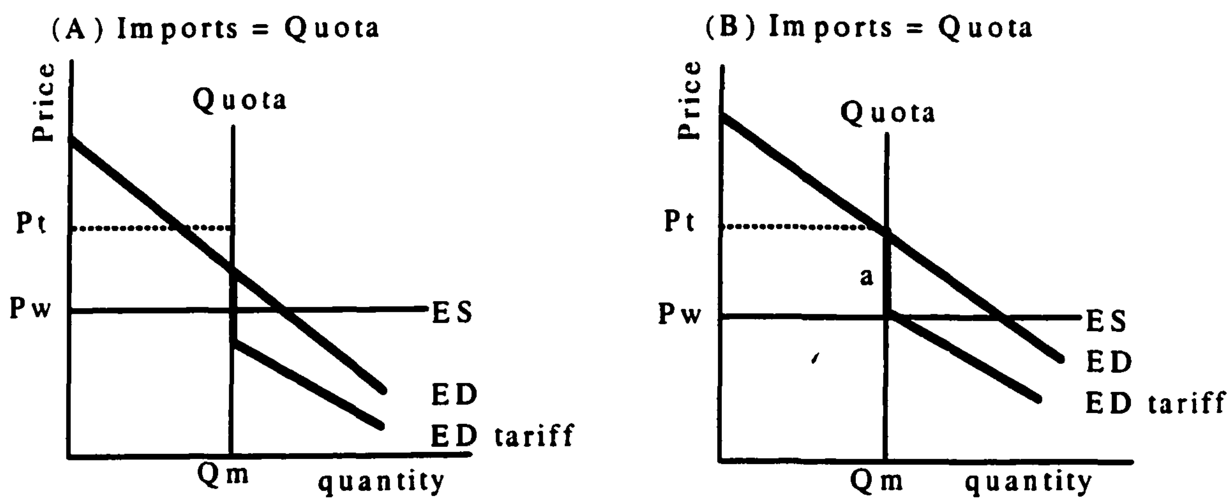

Fig 5.3. NAFTA policy for corn when imports equal the tariff-rate quota

tariff equivalents, which are then reduced. GATT is similar to NAFTA, except that GATT applies to imports from the world and not just from North America. Therefore, Mexico may import from other countries if the United States does not have the lowest price including transportation cost.

PROCAMPO involves removing domestic government intervention and aligning domestic prices with world prices. Guaranteed and agreement price supports will be phased out over a two-year transition period. Producers are provided an income support, which is decoupled from production decisions by producers. The income support is based on previous acreage harvested and yields. Income support is provided for up to 15 years, which facilitates the transition of producers to other productive sectors of society. The policy instruments and implementation into the model vary among crops.

Mexican producers are adjusting to the international policies prescribed under GATT and NAFTA and are beginning to make production decisions based on prices more closely aligned with international markets. Producers will no longer view government prices as the primary indicator of price movements, but are beginning to respond to domestic and international market forces that affect prices. This movement toward liberalization of agricultural markets is observed by producers as permanent, and the adjustment as transitory. Production decisions and investments should reflect this transition. Producers of wheat, soybeans, and sorghum are already responding to international prices. Wheat, soybeans, and sorghum were partially liberalized in 1989 by moving to an agreement price instead of the government guaranteed price. Mexican agricuitural policies vary depending upon the crop; for example, the major staples (corn and dry beans) have the strongest government intervention.

Diagrammatic Presentation of the Mexico Model

The agricultural sector contains seven crop sectors and three livestock sectors. The crop production systems are similar, except for the soybean sector, which is modeled in greater detail because it has the joint products of soybean meal and soybean oil.

The agricultural crops modeled consist of four basic systems, which differ by consumption as human food and animal feed. The four different systems are represented in Figures 5.4 through 5.7. The least detailed systems are those for corn, dry beans, rice, and barley because these commodities are utilized only as human food. Barley is modeled only as food and is used for beer production, although some barley is utilized as animal feed in Mexico. These commodities are presented in Figure 5.4. Only one commodity—sorghum—is used strictly as animal feed and is represented in Figure 5.5. Corn and wheat are major staple foods and are also used for feed in the pork and poultry industries. These commodities are represented in Figure 5.6. The most detailed commodity is soybeans because of the joint products of soybean meal and soybean oil and utilization for animal feed and human food. The soybean sector is modeled in Figure 5.7.

The conceptual structure for crop production is similar for all the commodities. Area harvested is determined by own farm price or guaranteed price and substitute crop prices. Substitute prices vary among the crops. The prices are not lagged because the government announces prices prior to planting. Yield is determined by own price and a time trend is used as a proxy for technology, such as new seed varieties and improved farming methods. A lagged dependent variable is occasionally used instead of a time trend. Production is an identity calculated as area harvested multiplied by yield. Total supply is

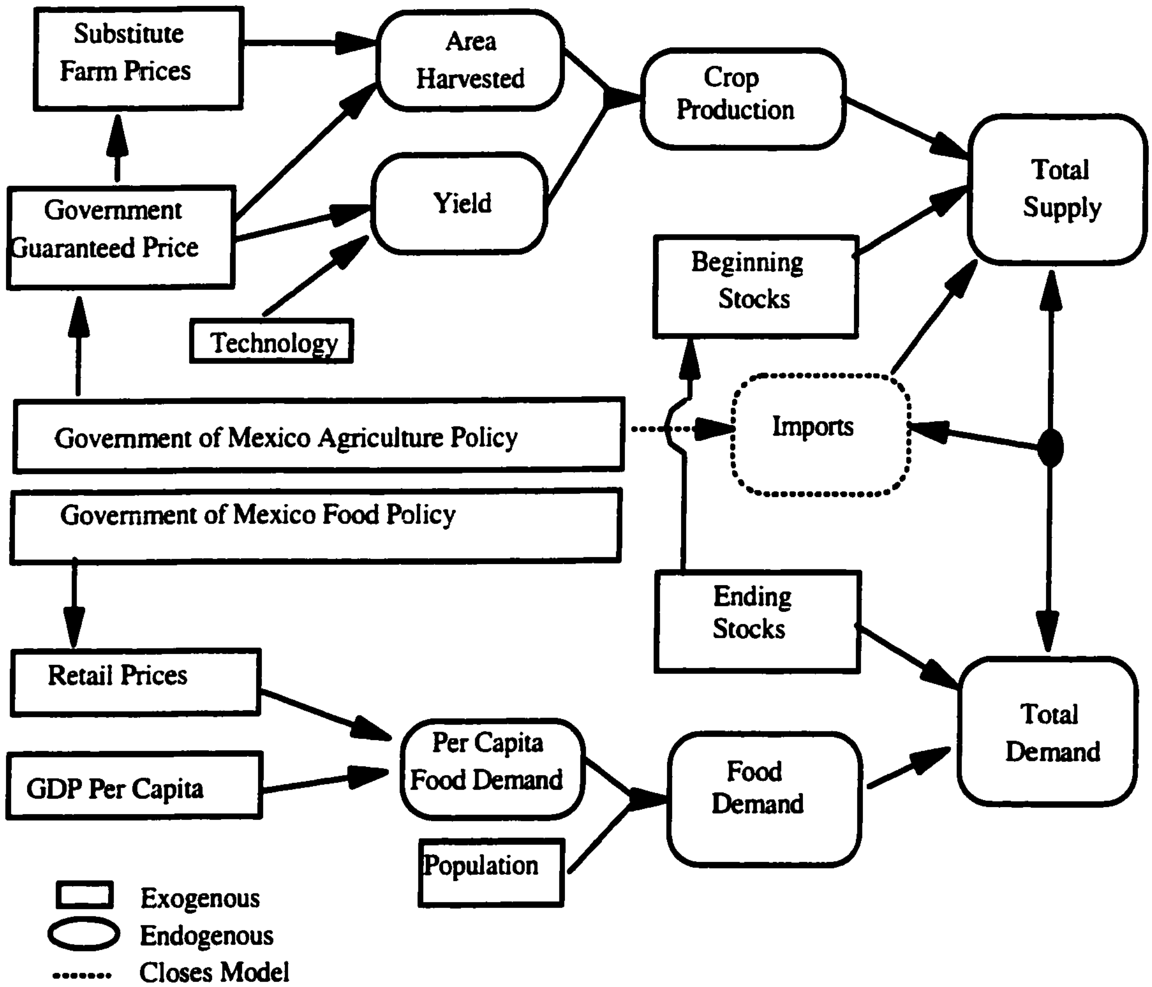

Figure 5.4. Dry bean, rice, and barley production, consumption, and trade in Mexico

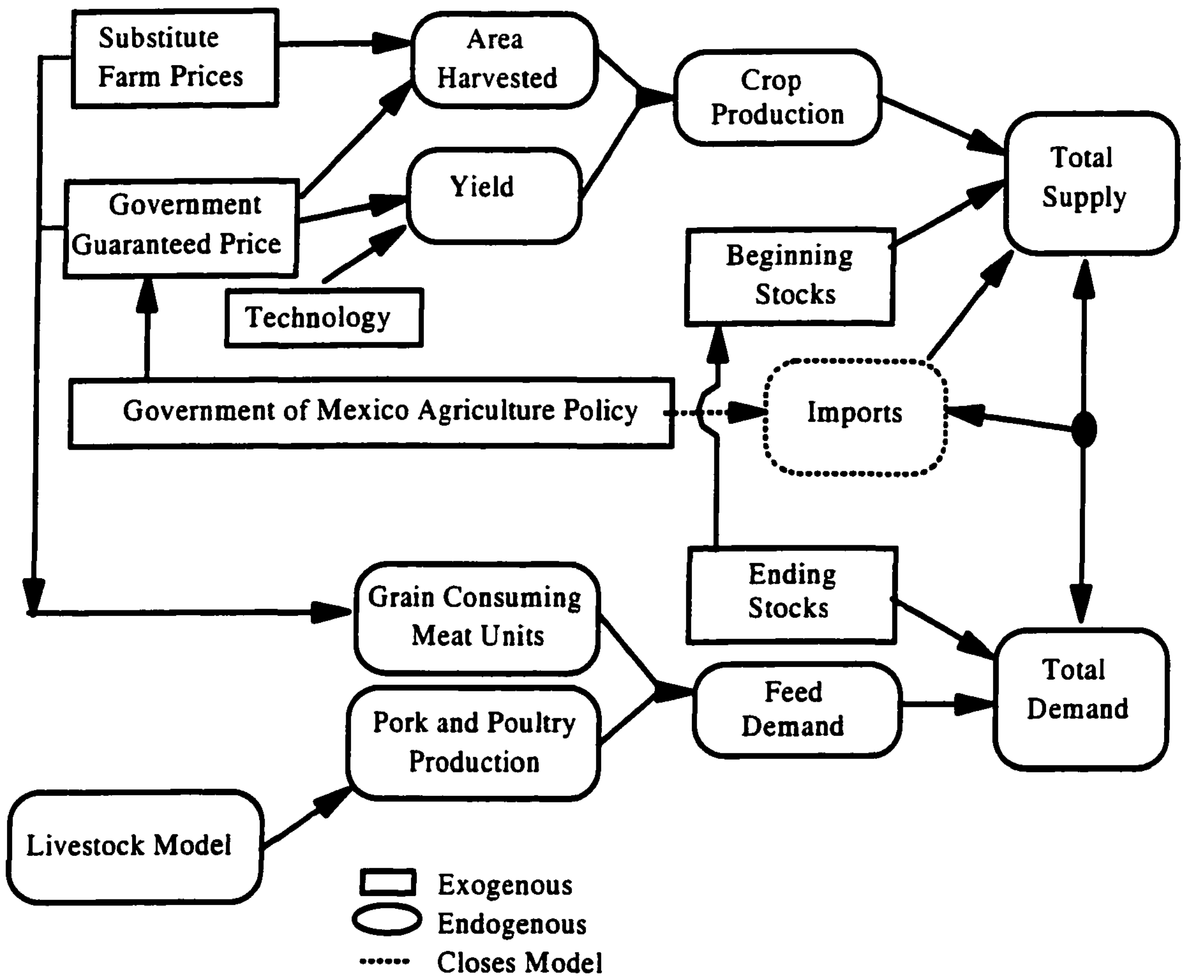

Figure 5.5. Sorghum production, consumption, and trade in Mexico

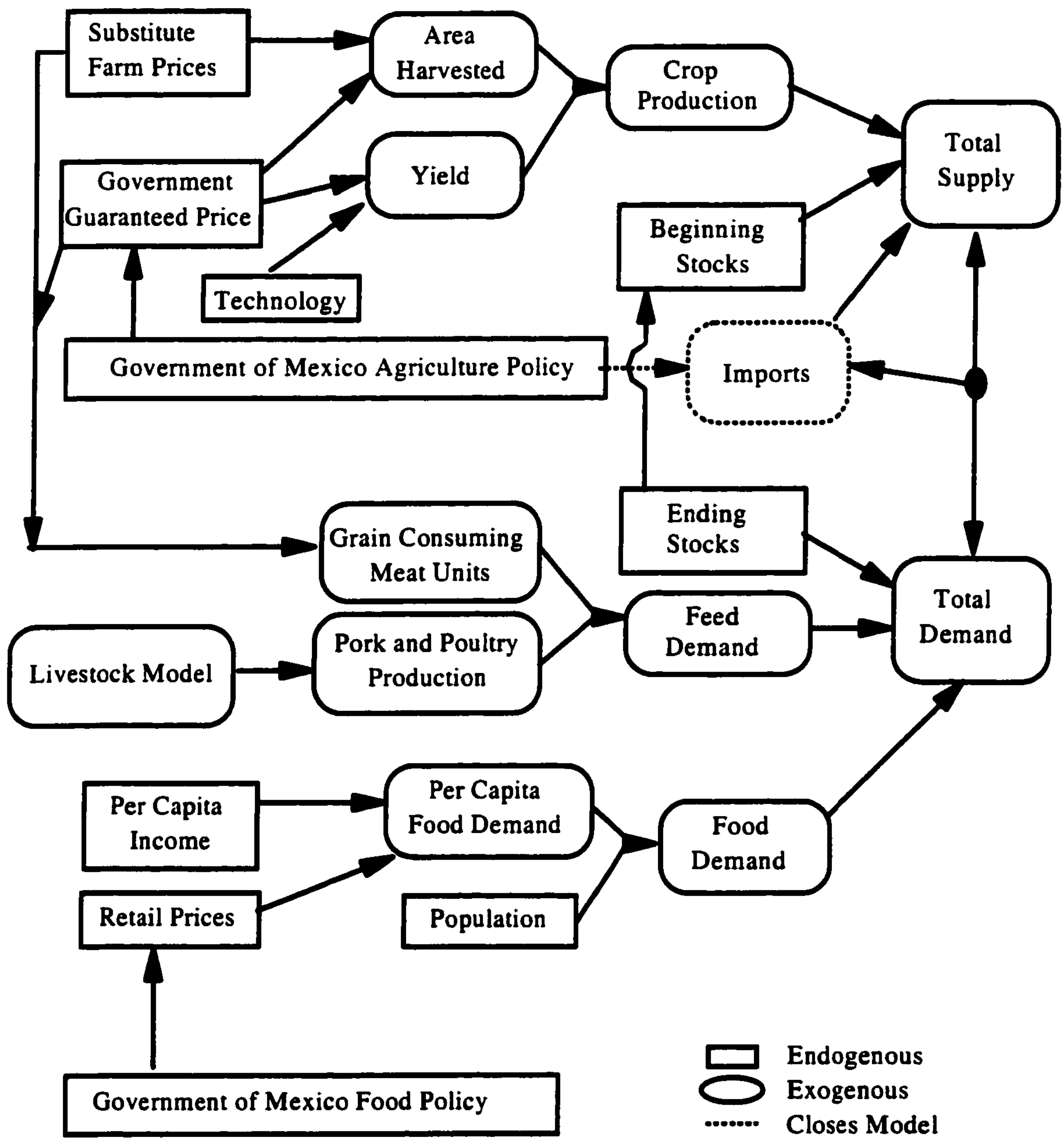

Figure 5.6. Corn and wheat production, consumption, and trade in Mexico

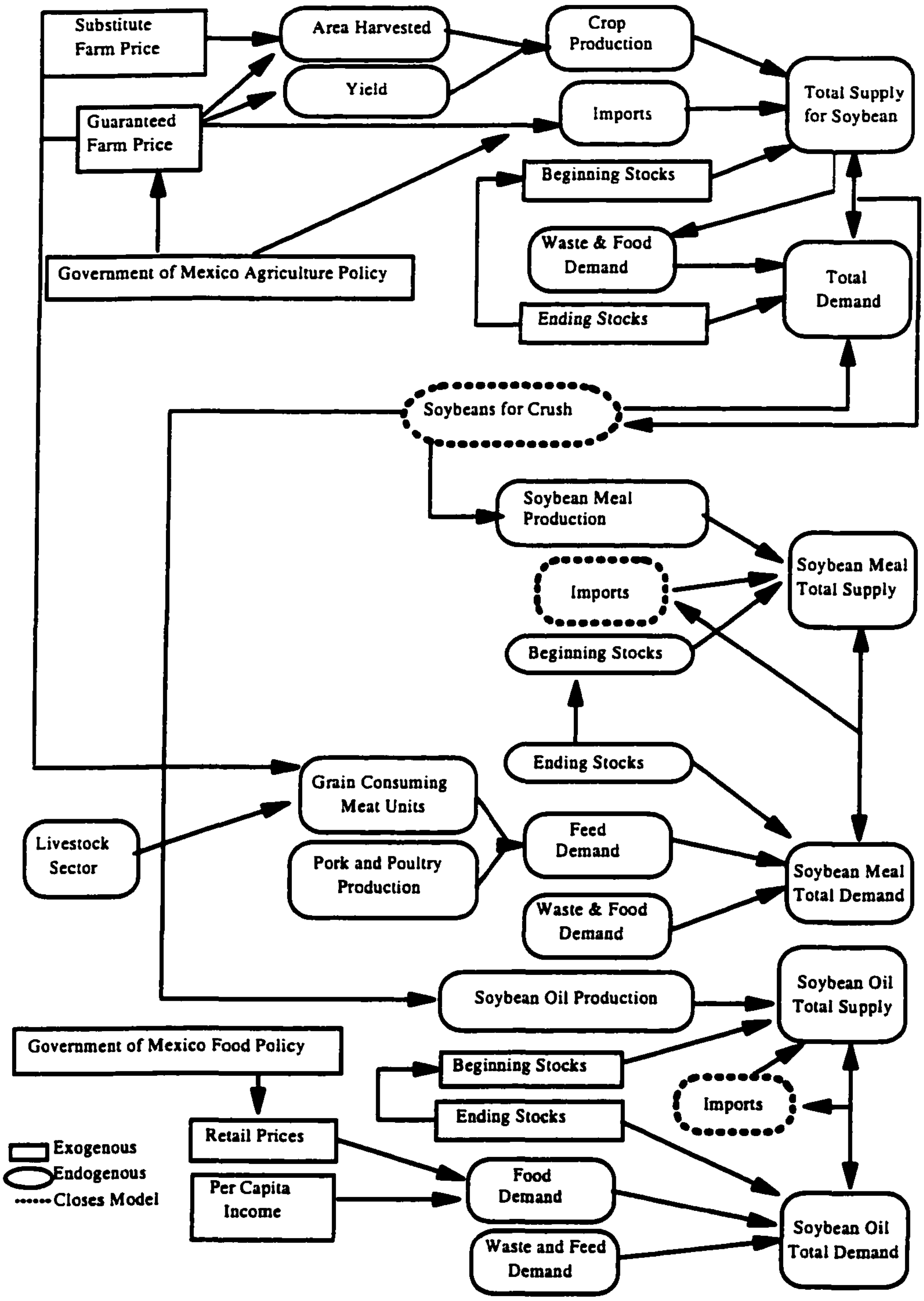

Figure 5.7. Soybeans, soybean meal, and soybean oil production, consumption, and trade in Mexico

equal to production plus imports plus beginning stocks. Ending stocks depend on the level of production. Imports are solved to close the model and provide equilibrium between production and consumption.

In Figures 5.4, 5.6, and 5.7, dry beans, rice, barley, corn, wheat, and soybean oil have per capita food consumption. Per capita consumption is determined by own price, substitute prices, per capita income, and occasionally lagged per capita consumption. Per capita income and retail prices are exogenous. Retail prices are determined by the government's food policy. Food demand is an identity, calculated as per capita consumption times population. Sorghum is not used for food consumption, as illustrated in Figure 5.5.

Feed demand is represented in Figures 5.5, 5.6, and 5.7 for sorghum, corn, wheat, and soybean meal. Feed demand is an identity equal to grain consuming meat units (GCMUs) times total poultry and pork production. A GCMU is the ratio of the commodity utilized as feed for the production of pork and poultry combined and provides an index for the amount of feed needed to produce a given quantity of meat. For example, the index for sorghum was 3.8 in 1996, which indicates that each kilogram of pork and poultry meat produced required 3.8 kilograms of sorghum. GCMUs depend on farm prices and guaranteed prices and, occasionally, a time trend to represent changes in technology. For example, the soybean meal GCMU has increased over the past 15 years as poultry and pork production operations have become larger and have increasingly used modern feed grain rations to minimize cost of gain and achieve a better daily rate of gain.

The soybean sector presented in Figure 5.7 appears to be complex but is actually quite similar to the other commodities. Production of soybeans is an identity, calculated as area harvested times yield. Area harvested and yield are determined by government guaranteed prices and substitute prices. Imports of soybeans do not close the system, but are determined by domestic prices and government policies. Soybeans utilized for crush is solved to close the system. Waste and food demand is determined by level of total supplies. Soybean meal and soybean oil are determined by supply of soybeans used for crush. Soybean meal and soybean oil imports are solved to close the system for soybean meal and oil. Soybean meal has a feed demand system similar to those for the other feed demand systems. Soybean oil has a food demand equation determined by retail prices and per capita income.

The cattle herd and beef production, consumption, and trade are presented in Figure 5.8. The cow herd ending inventory depends on the beginning inventory, the domestic beef carcass price, and the U.S. price for feeder cattle. The number of calves born is determined by the size of the cow herd. Cattle

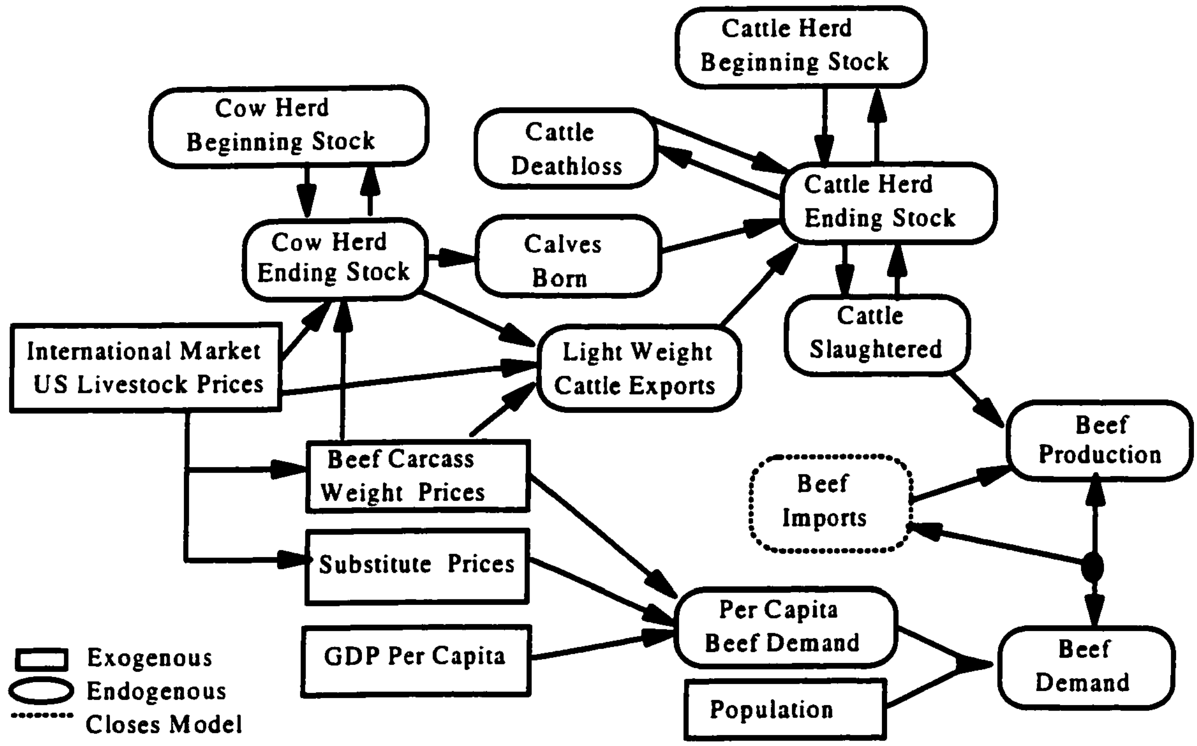

Figure 5.8. Beef production, consumption, and trade in Mexico

exports are determined by the size of the cow herd and the domestic and international prices of cattle. The cattle herd is an identity of calves born, total death loss, exports of light-weight cattle, cattle slaughtered, and beginning inventory. Beef production is determined by the number of cattle slaughtered. Per capita beef consumption depends on the domestic price of beef, prices of substitutes such as pork and poultry, and per capita income. Total beef demand is an identity of per capita consumption times the human population of Mexico. Beef imports are solved to close the system.

As shown in Figure 5.9, pork production depends on the total number of hogs slaughtered, which is determined by the size of the pig crop. The sow ending inventory is determined by the beginning inventory, which is an identity of the price of hogs and pigs in the United States and the domestic pork price. Pork consumption is similar in structure to beef and poultry consumption. Pork imports are solved to close the system.

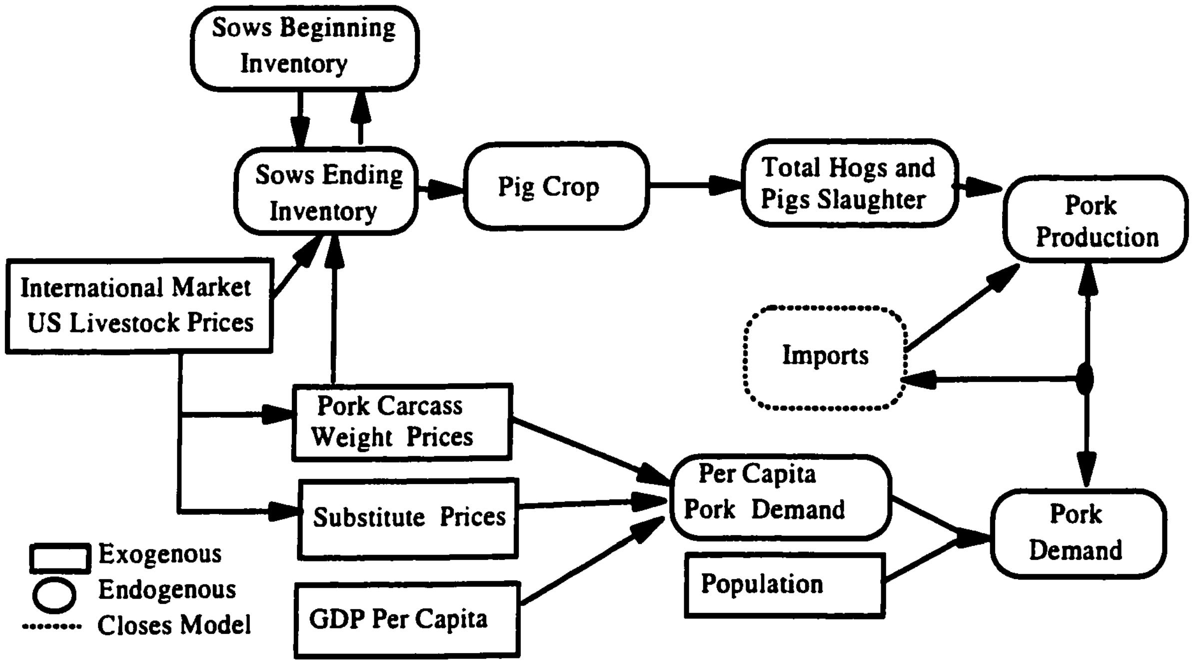

Figure 5.9. Pork production, consumption, and trade in Mexico

Model Specification in General Functional Form

The general functional form for the econometric model developed for Mexico's crop and livestock sectors is presented in Table 5.1. The model presents crop production, consumption for food and feed, and trade, and production, consumption, and trade for beef, pork, and poultry.

Crop production is an identity determined by yield times area harvested. The functional form used is double-log for most yield and area harvested equations. Producers respond to real prices in decisions such as application of fertilizer, herbicides, and insecticides, which affect yields. Therefore, yields are a function of own prices and input costs such as interest rates. The expected sign is given before the variable and no sign indicates that positive or negative is reasonable.

The prices used are guaranteed prices or farm prices, where • represents the seven different commodities with • = 1 to 7. The crops are corn, wheat, dry beans, rice, barley, sorghum, and soybeans. No substitute farm prices are used in the yield equations. Trend is a time trend, which represents a proxy for technology, since many crops exhibited growth in yield over the period of estimation due to new varieties and improved farming systems. The real interest rate is indicated by InterR and is expected to have a negative effect on yield. Only the rice yield equation has lagged yield instead of a time trend, which is a partial adjustment model with the coefficient on a lagged yield

Table 5.1 General specification of the Mexico Model

Agriculture Production

$Yield_i$ = f(+$FarmPrice_i$, -InterRate, +Trend, DM)

Area $Harvested_i$ = f(+$FarmPrice_i$, -$FarmPrice_s$, -InterRate, Trend, $AreaHarv_{i,t-1}$, DM)

$Production_i$ = $Yield_i$ * Area $Harvested_i$

Soybean Crush = Soybean Production + Beginning Stocks + Soybean Imports

- Soybean Feed Demand - Ending Stocks

Soybean Meal = 0.79 * SoybeanCrush

Soybean Oil = 0.18 * SoybeanCrush

Demand for Grain as Food and Feed

$FoodPerCap_i$ = f(-$RetailPrice_i$, +$RetailPrice_s$, +IncomePerCap, +$FoodPerCap_{i,t-1}$, DM)

$FoodConsump_i$ = $FoodPerCap_i$ * Population-Mexico

$GrainCMU_i$ = f(-$FarmP_i$, +$FarmP_s$, +$GrainCMU_{it-1,}$)

$FeedDemand_i$ = $GrainCPU_i$ * (PorkProd + PoultryProd)

Soybean Feed and Waste = 0.025 * (Producton + Ending Stocks + Imports)

Imports

Net $Imports_i$ = Production + Beginning Stocks - FoodConsump - FeedDemand - Ending Stocks

Demand for Meat

$MeatPerCap_i$ = f(-$CarcassP_i$, +$CarcassP_s$, +IncomePerCap, +$MeatPerCap_{i,t-1}$, DM)

$MeatConsump_i$ = $MeatPerCap_i$ * Population-Mexico

Livestock and Beef Production

CowHerdEndInv = f(+$BeefPrice_{t-1}$, +USSteerPrice, +$USsteerPrice_{t-1}$, CowHerdBegInv)

Calves born = f(+CowHerdBegInv)

CattleEndInv = CattleBegInv + Calvesborn - Cattle Slaughter - Cattle Death Loss - Cattle Export

Cattle Death Loss = f(+CattleBegInv)

Cattle Slaughter = f[+(CattleEndInv - CowHerdEndInv), +BeefPrice, -USSteerPrice,

+FeedPrice, CattleSlaught-1]

Beef Production = f(+Cattle Slaughter, Trend)

Beef Imports = Beef Consumption - Beef Production

Cattle Exports = f(+USsteerPrice, +CowHerdEndInv, Trend)

Table 5.1 (continued)

Pork Production
SowEndInv = f(+SowBegInv, +PorkPrice$_{t-1}$, -FeedPrice, -NinRate$_{t-1}$)
SowBegInv = SowEndInv$_{t-1}$
Pigs Born = f(SowBegInv, DM)
Hogs and Pigs Slaughter = f[+(PigsBorn, +PigsBorn$_{t-1}$)/2, +PorkPrice, -FeedPrice]
Pork Production = f(+Hogs and Pigs Slaughter)
Pork Imports = PorkmeatCons - Pork Production

between zero and one. DM represents dummy variables used for large decreases in yields and harvested area due to droughts. Most of Mexico's agriculture depends on rain.

Area harvested for the different crops is determined by the own farm price and the farm price of substitute crops, with expected positive and negative signs, respectively. Interest rates are expected to have a negative effect on area harvested. Some commodities have a time trend of lagged area harvested. Crop production is an identity of yield times area harvested. The supply of soybeans for crushing is determined by an identity. Soybean crush produces soybean meal and soybean oil, which are derived through identities of 0.79 and 0.18 times soybean crush, respectively.

Demand for crop production consists of food and feed demand and soybean feed and waste. Per capita food consumption, FoodPerCap$_{i,}$ is determined by retail price, per capita income, and lagged per capita consumption. Own retail price is negative and substitute retail prices are positive. Per capita income is positive for most commodities.

Feed demand is derived from GCMUs, GrainCMU$_i$, times pork and poultry production. GCMUs are a function of own price, substitute feed prices, and lagged GrainCMU. As own price increases, producers shift to lower-cost feeds. The ratio, GrainCMU, will decrease, thereby decreasing feed demand for this commodity. Soybean feed and waste is an identity of 2.5 percent of total soybean supply. Net imports are derived from identities to close the model. Ending stocks are exogenous based on the average level during the past 10 years.

Meat demand is estimated with OLS in double-log functional form. Per capita consumption, MeatPerCap$_{i,}$, is a function of own carcass price, substitute carcass prices, per capita income, and lagged per capita consumption. Own price is expected to be negative and substitutes have a positive sign. Per capita income is expected to be positive.

The cow herd is expected to increase as the U.S. steer price increases. Calves born is determined by size of the cow herd. Total cattle slaughter is a function of the cattle inventory, domestic beef prices, U.S. prices, feed prices, and lagged cattle slaughter. Increases in the cattle herd relative to the cow herd and higher domestic beef prices will increase slaughter. Higher U.S. prices will lower slaughter as more cattle are exported to the United States. Higher feed prices are expected to increase slaughter. Beef production is determined by the number of cattle slaughtered. Beef imports equal domestic consumption less production. As U.S. feeder prices increase, greater numbers of Mexican light-weight cattle are exported to the United States.

Sow inventory is positive to pork prices and negative to feed price and interest rates. Pigs born is a function of sow inventory. The number of hogs and pigs slaughtered increases as the size of the pig crop and pork prices increase. Slaughter decreases as the cost of feed increases. Pork imports are determined by the identity of consumption less domestic production.

CHAPTER 6. EMPIRICAL ESTIMATION AND SIMULATION VALIDATION

This chapter presents the estimated Mexican agricultural model for Mexico, including data sources, choice of estimator, variable nomenclature, and the estimated model with results of estimation and important statistics. Alternative specifications are also estimated for the model. The final section discusses simulation statistics and the model's simulation performance.

Crop and Livestock Data

Data for Mexico's production, consumption, trade, and ending stocks for corn, wheat, soybean, sorghum, rice, and barley were obtained from the U.S. Department of Agriculture's Economic Research Service. The dry bean data were obtained from the Mexican Ministry of Agriculture. Livestock, meat production, and meat consumption data for Mexico were obtained from U.S. Department of Agriculture, Economic Research Service. Price data were obtained from a variety sources. Mexico's guaranteed prices were available from numerous sources. The *Mexican Agriculture Databook* by Texas Agricultural Market Research Center (1990) provided both guaranteed and producer prices. U.S. Department of Agriculture, Foreign Agricultural Service reports from the U.S. Embassy in Mexico provided farm and retail prices for 1993 through 1999 (USDA 1993-2000). Retail prices for corn and wheat were taken from Meilke (1990). All macroeconomic data were obtained from the International Monetary Fund's *International Financial Statistics Yearbook 1999* and monthly publications (International Monetary Fund 1999, 2000).

Estimation Procedures

The Mexican model has seven different sections, which are estimated separately. The supply side includes crop production, beef production, pork production, and poultry production. The demand sector consists of a feed demand system for livestock and a meat demand system and a grain food demand system for humans. The estimators initially tried for production were Ordinary Least Squares (OLS) and then Two-Stage Least Square (2SLS). Estimators used for demand equations were OLS, 2SLS, and Seemingly Unrelated Regression (SUR). Eventually, OLS was used as the estimator for production and demand equations, even though it has limitations with respect to specific properties.

The OLS estimator is the most appropriate estimator under these specific conditions:

1. the dependent variable is a linear function of a specific set of exogenous variables;
2. $Yi = \forall_0 + \exists_1 X_{1i} + \exists_2 X_{2i} + \ldots + \exists_n X_{ni} + ,_i$;

3. the independent variables are considered fixed in repeated samples and nonstochastic;
4. the expected value of the disturbance term is zero $E(,_i) = 0$;
5. the observations of disturbance terms all have uniform variance and are not correlated to each other, $E(,_i,_i) = \Phi^2$, $E(,_i,_r) = 0$; and,
6. the error term is normally distributed.

If the listed conditions are satisfied, then the OLS estimator will have the desired finite (small) sample properties: unbiasedness, efficiency, and Best Linear Unbiased Estimator (BLUE). The OLS estimator will also have the desired asymptotic sample properties of asymptotic unbiasedness, consistency, and asymptotic efficiency (Kementa 1986; Greene 1990).

The crop production system initially seems to satisfy the above criteria for the OLS estimator. The farm price and government guaranteed price are exogenous and the system is recursive. However, upon closer observation, three of the fifteen estimated equations have lagged dependent variables: rice yield, dry bean harvested area, and barley harvested area. The partial adjustment model violates the criteria of lagged dependent variable and autocorrelated errors. This situation may result in an asymptotic biased estimator (Kennedy 1992: 142). If the lagged dependent variable is contemporaneously correlated with the autocorrelated disturbance, the OLS estimator results in asymptotic bias. However, the OLS estimator may not be biased if the disturbance term is white noise. If the disturbance term is serially independent, then OLS will be asymptotically normal and efficient, but there will be finite sample bias (Johnston 1984: 362). The appropriate estimator for lagged dependent variables and autocorrelated disturbances is an Instrumental Variables (IVs), or Maximum-Likelihood.

The OLS estimator is often chosen over the IV estimator because the information set used to estimate the coefficient is now smaller and results in higher variances than the OLS estimator (Kennedy 1992: 144). In estimating the crop production system with IVs, results were statistically lower and the values of coefficients were smaller.

The demand systems for meat and grains were estimated with an OLS estimator. The demand system is not simultaneous, but in the system the equations may be correlated because of the error terms. For example, a shock affecting one demand function may spill over, affecting demand functions of similar goods. The Seemingly Unrelated Regression Equation (SURE) estimator estimates the system as a set using a single regression, which will improve efficiency (Kennedy 1992: 164). As the correlation between the disturbances increases and correlation between different sets of explanatory variables decreases, the efficiency gained from using SURE as opposed to OLS increases (Johnston 1984: 338). However, some equations in the demand systems have lagged dependent variables, which can lead to inconsistent estimators (Kementa 1986: 648). Coefficients and statistical results showed little difference when comparing OLS and SURE estimators in the demand systems.

The beef and pork production systems are simultaneous equations. A change in any disturbance term changes all the endogenous variables because the equations are determined simultaneously. The second assumption of independent variables considered fixed in repeated samples and nonstochastic is violated. Violation of the second assumption leads to an OLS estimator that is biased in small samples and asymptotically (Kennedy 1992: 151). IV is most suitable to produce consistent estimators. The appropriate partial estimators are 2SLS and Limited Information Maximum Likelihood (LI/ML). The full information estimators are Three-Stage Least Squares (3SLS) and Full Information Maximum Likelihood (FI/LI) (Greene 1990).

Under full information systems, if the system is misspecified, then all structural parameters are affected. Also, a specification error in any equation can lead to estimation bias in other equations (Johnston 1984: 489). Because of difficulty in working with Mexican data and the simplification of the livestock sector in this model, the full information system estimators are not appropriate.

The OLS estimator may still be considered a viable estimator under specific conditions in a simultaneous system. The OLS estimator is biased in small samples, but so are all alternative estimators. The OLS will have the minimum variance among these estimators. Research with Monte Carlo studies indicates that this is true only with very small samples. Monte Carlo studies also indicate that OLS estimator properties are less sensitive than are alternative estimators when multicollinearity, errors in variables, and misspecifications are present, especially under small samples (Kennedy 1992: 158). The sample size is 20 observations for 1975-95 for the livestock equations in the Mexican model. Also, the quality of data for Mexico's agriculture is usually considered quite low among agricultural economists.

Variable Nomenclature and Definition

The following variable definitions are relatively easy to use. The first two letters represent the commodity; for example CO is for corn. The third letter represents the general characteristic such as area, A; yield, Y; and supply, S. The fourth and fifth letters represent more specifically the characteristic of the variable; for example, HA is hectares and MT is total imports. The last two letters represent the country, where MX is Mexico. The complete variable nomenclature is presented in Table 6.1. Two examples of the nomenclature are COYHAMX, where CO is corn, Y is yield, HA

Table 6.1. Variable nomenclature

CO-----	Corn	SO-----	Soy oil	HP-----	Hogs and pigs
WH----	Wheat	SM-----	Soy meal	SW-----	Sows
SG-----	Sorghum	CT-----	Cotton	PG-----	Pigs
DB-----	Dry beans	CE-----	Cattle	PO-----	Pork
BA-----	Barley	BW----	Beef cows	PY-----	Poultry
RI------	Rice	CV-----	Calves	LY-----	Layers
SB-----	Soy beans	BE-----	Beef	EG-----	Eggs
--Y-----	Yield	--S-----	Supply	--P-----	Prices
--A-----	Area	--U-----	Utilization	--C-----	Stocks
---HA--	Hectares	---PR--	Production	---FM--	Farm
---MT--	Imports total	---XT--	Exports total	---GA--	Guaranteed
---MN--	Net imports	---XN--	Net exports	---RT--	Retail
---IT--	Beginning stocks	---OT--	Ending stocks	---WH--	Wholesale
---DC--	Domestic consumption	---FO--	Food	---CR--	Carcass
---FE--	Feed	---TN--	Total numbers	---LW--	Live weight
---DL--	Death loss	---NB--	Number born	---TT--	Total quantity

is hectares, and MX is Mexico, and WHUDCMX, where WH is wheat, U is utilization, DC is domestic consumption, and MX is Mexico. A few variables do not adhere to this nomenclature, but they are similar. Supply, S, and utilization, U, are used the most because these variables indicate what enters the system and what leaves the system, respectively.

Empirical Results and Identities

Tables 6.2 through 6.9 document the Mexican grain and livestock model with 144 equations, of which 41 are estimated and 103 are identities. The tables cover crop production, grain food consumption, feed demand, trade and identities for total supply, cattle supply and beef production, pork production, poultry production, and meat demand.

Table 6.2 covers crop production for corn, wheat, dry beans, rice, sorghum, soybeans, and barley. The crops are specified according to the biological nature of production. Prices and quantity are not simultaneously determined because of government price support policy and import restrictions through quotas. The estimated parameters are given, and the t-statistics are listed below the coefficients. The time period used for estimation, R^2 and adjusted R^2 statistics, standard error, Durbin-Watson, and mean of estimated variables are provided below the estimated equation.

Corn Production

Corn yield, COYHAMX, in equation (6.1) was estimated over the period 1975-95. A time trend, TIME, was used in the equation as a proxy for increasing yields due to research in new varieties and more efficient production practices. The time trend is positive and significant. Lagged interest has

Table 6.2. Empirical results for crop production (6.1) Corn yield (mt/ha)

COYHAMX = 0.085021 + 0.065007 * (TIME) - 0.00434134 * lag(NIINTRMX)
(0.63) (11.59) (-1.56)

- 0.313219 * DM82
(- 2.21)

Fit over:	1975-1995	R-squared:	0.9072	Standard Error:	0.115
LHS Mean:	1.6877	Adj. R-squared:	0.8908	Durbin-Watson:	1.690

(6.2) Corn area harvested in logs (1,000 hectares)

COAHAMXL = 8.825044 + 0.196042 * log(COPFMMX /CPI85MXe)
(33.97) (2.29)

- 0.168180 * log(SGPFMMX /CPI85MXe)
(-2.24)

+ 0.024378 * log(DBPFMMX /CPI85MXe) - 0.22387 * DM8290
(0.58) (-7.22)

- 0.04478 * log(CTAHAMX) - 0.0025944 * lag(NIINTRMX)
(-1.87) (-2.28)

Fit over:	1965-1995	R-squared:	0.9073	Standard Error:	0.039
LHS Mean:	8.87	Adj. R-squared:	0.8841	Durbin-Watson:	2.440

(6.3) Corn area harvested (1,000 hectares)

COAHAMX = exp(COAHAMXL)

(6.4) Corn production (1,000 mt)

COSPRMX = COYHAMX * COAHAMX

(6.5) Wheat yield in logs (mt/ha)

WHYHAMXL = -22.518010 + 0.119819 * log (WHPGAMXe /CPI85MXe)
(-4.71) (2.70)

+ 0.011678 * TIME - 0.190256 * DM7778 - 0.231550 * DM9192
(4.94) (-4.05) (-4.90)

Fit over:	1975-1995	R-squared:	0.8109	Standard Error:	0.0597
LHS Mean:	3.8509	Adj. R-squared:	0.7664	Durbin-Watson:	2.3770

(6.6) Wheat yield (mt/ha)

WHYHAMX = exp(WHYHAMXL)

Table 6.2. (continued)

(6.7) Wheat harvested area in logs (1,000 ha)

WHAHAMXL = 6.591601 + 0.207129 * log(WHPFMMX /CPI85MXe)
(9.35) (1.02)

+ 0.064508 * log(SBPGAMXe /CPI85MXe) - 0.1 * log(RIPFMMX /CPI85Mxe)
(0.83)

- 0.05681 * log(SGPGAMXe /CPI85MXe) - 0.108357 * log(CTAHAMX)
(-0.4) (-1.94)

- 0.246738 * DM79 + 0.130915 * DM86 + 0.165434 * DM82ON
(-3.13) (1.52) (3.38)

Fit over:	1965-1995	R-squared:	0.7674	Standard Error:	0.075
LHS Mean:	6.7716	Adj. R-squared:	0.6966	Durbin-Watson:	1.803

(6.8) Wheat area harvested (1,000 ha)

WHAHAMX = exp(WHAHAMXL)

(6.9) Wheat production (1,000 mt)

WHSPRMX = WHYHAMX * WHAHAMX

(6.10) Rice yield in logs (mt/ha)

RIYHAMXL = 0.055746 * log(RIPFMMX /CPI85MXe) + 0.237038 * log[lag(RIYHAMX)]
(3.18) (1.81)

+ 0.206599 * DM7183 + 0.377794 * DM84on
(2.63) (4.43)

Fit over:	1975-1995	R-squared:	0.7847	Standard Error:	0.202
LHS Mean:	0.8557	Adj. R-squared:	0.7467	Durbin-Watson:	na

(6.11) Rice area harvested in logs (1,000 ha)

RIAHAMXL = 4.870781 + 0.19694 * log(RIPGAMXe /CPI85MXe) + 0.328273 * DM75
(4.38) (1.04) (2.17)

- 0.078275 * log(WHPFMMX /CPI85MXe) - 0.771755 * DM90ON + 0.240387 * DM85
(-0.44) (-8.45) (1.63)

Fit over:	1965-1995	R-squared:	0.8568	Standard Error:	0.144
LHS Mean:	4.7818	Adj. R-squared:	0.8281	Durbin-Watson:	2.53

(6.12) Rice area harvested (1,000 ha)

RIAHAMX = exp(RIAHAMXL)

(6.13) Rice production (1,000 mt)

RISPRMX = RIYHAMX * RIAHAMX

Table 6.2. (continued)

(6.14) Dry bean yield (mt/ha)

DBYHAMX = 0.410371 + 0.0000137 * (DBPFMMX/CPI85MXe) + 0.00848664 * (TIME)
(10.14) (0.45) (7.40)

- 0.0025551 * (NIINTRMX) - 0.122888 * DM77 - 0.168804 * DM8889
(-2.47) (-2.43) (-4.46)

Fit over:	1965-1995	R-squared:	0.7518	Standard Error:	0.048
LHS Mean:	0.5958	Adj. R-squared:	0.7022	Durbin-Watson:	1.791

(6.15) Dry bean area harvested in logs (1,000 ha)

DBAHAMXL = 5.336213 + 0.10 * log(DBPGAMXe /CPI85MXe) - 0.526284 * DM79
(5.13) (-4.10)

+ 0.196678 * lag(DBAHAMXL) - 0.374579 * DM89 - 0.359132 * DM92
(1.41) (-2.91) (-2.78)

Fit over:	1965-1995	R-squared:	0.498	Standard Error:	0.135
LHS Mean:	7.427	Adj. R-squared:	0.421	Durbin-Watson:	na

(6.16) Dry bean area harvested (1,000 ha)

DBAHAMX = exp(DBAHAMXL)

(6.17) Dry bean production (1,000 mt)

DBSPRMX = DBYHAMX * DBAHAMX

(6.18) Soybean yield was set exogenous

(6.19) Soybean area harvested in logs (1,000 ha)

SBAHAMXL = -5.518268 + 1.226348 * log(SBPFMMX /CPI85MXe)
(-2.06) (4.03)

+ 0.514561 * log(WHPFMMX /CPI85MXe) + 1.301612 * log(TIME)
(1.22) (9.49)

- 0.624274 * log(RIPFMMX /CPI85MXe) - 0.692937 * DM80 - 1.030414 * DM88
(-1.96) (-2.26) (-3.33)

Fit over:	1965-1995	R-squared:	0.8391	Standard Error:	0.298
LHS Mean:	5.604	Adj. R-squared:	0.7989	Durbin-Watson:	1.496

(6.20) Soybean area harvested (1,000 ha)

SBAHAMX = exp(SBAHAMXL)

(6.21) Soybean production (1,000 mt)

SBSPRMX = SBYHAMX * SBAHAMX

(6.22) Soybeans utilized for crushing (1,000 mt)

SBUCRMX = SBSTTMX - SBUFEMX - SBCOTMX

Table 6.2. (continued)

(6.23) Soybean meal crush (1,000 mt)
SMSCRMX = SBUCRMX

(6.24) Soybean meal production (1,000 mt)
SMSPRMX = 0.79 * SMSCRMX

(6.25) Soybean oil production (1,000 mt)
SOSPRMX = 0.18 * SMSCRMX

(6.26) Sorghum yield (mt/ha)
SGYHAMX = 0.00087373 * (SGPFMMX /CPI85MXe) + 0.029852 * TIME
(2.47) (8.22)

- 0.00386811 * lag(NIINTRMX) - 0.592324 * DM72 - 0.56533 * DM79
(-1.52) (-4.61) (-4.41)

+ 0.612358 * DM80
(4.7)

Fit over:	1965-1995	R-squared:	0.8515	Standard Error:	0.124
LHS Mean:	2.91	Adj. R-squared:	0.8812	Durbin-Watson:	2.136

(6.27) Sorghum area harvested in logs (1,000 ha.)
SGAHAMXL = 5.052932 + 0.464909 * log(SGPFMMX /CPI85MXe)
(5.11) (1.46)

- 0.364826 * log(COPFMMX /CPI85MXe) + 0.510890 * log(TIME)
(-0.97) (7.2)

Fit over:	1965-1995	R-squared:	0.6672	Standard Error:	0.195
LHS Mean:	7.1186	Adj. R-squared:	0.6302	Durbin-Watson:	1.46

(6.28) Sorghum area harvested (1,000 ha.)
SGAHAMX = exp(SGAHAMXL)

(6.29) Sorghum production (1,000 mt)
SGSPRMX = SGYHAMX * SGAHAMX

(6.30) Barley yield (mt/ha)
BAYHAMX = - 0.359156 + 0.642504 * log(TIME) - 0.258020 * DM7982
(-3.31) (17.19) (-4.30)

Fit over:	1965-1995	R-squared:	0.9150	Standard Error:	0.086
LHS Mean:	1.669	Adj. R-squared:	0.9090	Durbin-Watson:	1.676

(6.31) Barley area harvested in logs (1,000 ha)
BAAHAMXL = 3.019933 + 0.108991 * log(BAPGAMXe /CPI85MXe)
(3.5) (1.35)

+ 0.328513 * lag(BAAHAMXL) + 0.16538 * DM7580
(2.28) (3.6)

Table 6.2. (continued)

Fit over:	1965-1995	R-squared:	0.55	Standard Error:	0.093
LHS Mean:	5.51	Adj. R-squared:	0.51	Durbin-Watson:	na

(6.32) Barley area harvested (1,000 ha)
BAAHAMX = exp(BAAHAMXL)

(6.33) Barley production
BASPRMX = BAYHAMX * BAAHAMX

Variable definitions:

Endogenous variables:

COYHAMX:	Corn yield (mt/ha)
COAHAMX:	Corn area harvested (1,000 ha)
COAHAMXL:	Corn area harvested (1,000 ha) in logs
COSPRMX:	Corn production (1,000 mt)
WHYHAMX:	Wheat yield (mt/ha)
WHYHAMXL:	Wheat yield (mt/ha) in logs
WHAHAMX:	Wheat area harvested (1,000 ha)
WHSPRMX:	Wheat production (1,000 mt)
DBYHAMX:	Dry bean yield (mt/ha)
DBAHAMX:	Dry bean area harvested (1,000 ha)
DBAHAMXL:	Dry bean area harvested (1,000 ha) in logs
DBSPRMX:	Dry bean production (1,000 mt)
RIYHAMX:	Rice yield (mt/ha)
RIAHAMX:	Rice area harvested (1,000 ha)
RISPRMX:	Rice production (1,000 mt)
SGYHAMX:	Sorghum yield (mt/ha)
SGAHAMX:	Sorghum area harvested (1,000 ha)
SGAHAMXL:	Sorghum area harvested (1,000 ha) in logs
SGSPRMX:	Sorghum production (1,000 mt)
SBYHAMX:	Soybean yield (mt/ha)
SBAHAMX:	Soybean area harvested (1,000 ha)
SBAHAMXL:	Soybean area harvested (1,000 ha) in logs
SBSPRMX:	Soybean production (1,000 mt)
SMYHAMX:	Soy meal yield (mt/ha)
SMSCRMX:	Soy meal crushed (1,000 mt)
SMSPRMX:	Soy meal production (1,000 mt)
SOSPRMX:	Soy oil production (1,000 mt)
BAYHAMX:	Barely yield (mt/ha)
BAAHAMX:	Barely area harvested (1,000 ha)
BAAHAMXL:	Barely area harvested (1,000 ha) in logs
BASPRMX:	Barely production (1,000 mt)

Exogenous variables:

COPFMMX:	Corn market farm price (pesos/mt)
SGPFMMX:	Sorghum farm market price (pesos/mt)
DBPFMMX:	Dry bean farm market price (pesos/mt)
WHPFMMX:	Wheat farm market price (pesos/mt)
SBPFMMX:	Soybean farm market price (pesos/mt)
RIPFMMX:	Rice farm market price (pesos/mt)

Table 6.2. (continued)

COPGAMXe:	Corn government guaranteed farm market price (pesos/mt)
SGPGAMXe:	Sorghum government guaranteed farm market price (pesos/mt)
DBPGAMXe:	Dry bean government guaranteed farm market price (pesos/mt)
WHPGAMXe:	Wheat government guaranteed farm market price (pesos/mt)
SBPGAMXe:	Soybeans government guaranteed farm market price (pesos/mt)
RIPGAMXe:	Rice government guaranteed farm market price (pesos/mt)
BAPGAMXe:	Barely government guaranteed farm market price (pesos/mt)
CTAHAMX:	Cotton harvested area (1,000 ha)
CPI85MXe:	Consumer price index in 1985 pesos (1985=100)
NIINTRMX:	Real interest rate
TIME:	Time trend beginning with 1 in 1960
DM69:	Dummy variable: 1 in 1975 0 otherwise
DM72:	Dummy variable: 1 in 1975 0 otherwise
DM75:	Dummy variable: 1 in 1975 0 otherwise
DM76:	Dummy variable: 1 in 1976 0 otherwise
DM77:	Dummy variable: 1 in 1977 0 otherwise
DM79:	Dummy variable: 1 in 1979, 0 otherwise
DM80:	Dummy variable: 1 in 1980, 0 otherwise
DM82:	Dummy variable: 1 in 1982, 0 otherwise
DM85:	Dummy variable: 1 in 1985, 0 otherwise
DM86:	Dummy variable: 1 in 1986, 0 otherwise
DM89:	Dummy variable: 1 in 1989, 0 otherwise
DM92:	Dummy variable: 1 in 1992, 0 otherwise
DM6074:	Dummy variable: 1 in 1960 through 1974, 0 otherwise
DM7378:	Dummy variable: 1 in 1973 through 1978, 0 otherwise
DM7580:	Dummy variable: 1 in 1975 through 1980, 0 otherwise
DM7778:	Dummy variable: 1 in 1977 through 1978, 0 otherwise
DM7982:	Dummy variable: 1 in 1979 through 1982, 0 otherwise
DM8290:	Dummy variable: 1 in 1982 through 1990, 0 otherwise
DM8889:	Dummy variable: 1 in 1988 and 1989, 0 otherwise
DM9192:	Dummy variable: 1 in 1991 through 1992, 0 otherwise
DM75ON:	Dummy variable: 1 beginning in 1975, 0 otherwise
DM82ON:	Dummy variable: 1 beginning in 1982, 0 otherwise
DM90ON:	Dummy variable: 1 beginning in 1990, 0 otherwise

the expected negative sign, but the results are not significantly different from zero. The intercept shift dummy variable for 1982 indicates a decrease in yields due to a drought and is significant. The coefficient of determination is quite high, at 0.90.

Corn area harvested, COAHAMX, in equation (6.2), is estimated in double-log form over the period 1965-95. The independent variables include real corn farm price, sorghum farm price, dry bean farm price, cotton harvested area, real interest rate, and an intercept shift dummy variable from 1982 to 1990. The prices are not lagged because the government guaranteed price is announced prior to planting. All the prices are expressed in real terms by being deflated by Mexico's consumer price index.

For corn area harvested, COAHAMX, in equation (6.2) the farm price is significant, with the right sign and an elasticity of 0.196. This elasticity is also the largest among the other prices, which is consistent with our expectations because we expect the commodity own price to have the greatest impact on area harvested. Sorghum farm price has the expected negative sign and is statistically significant. The sorghum price elasticity is -0.168, which is consistent with our expectations. Sorghum farm price has the largest impact on corn harvested area after corn own price, which is expected. Substitution between corn and sorghum occurs mostly in the Bajio region, which includes the states of Guanajuato, Jalisco, and Michoacan.

The dry bean price is not statistically significant, but the sign is consistent with expectations because corn and dry beans are often planted in alternating rows because of the biological benefits from nitrifixation in the beans. The cotton harvested area is used as a proxy for cotton price, which is almost statistically significant at 1.87 and exhibits the expected sign, with an elasticity of -0.045. Substitution between corn and cotton occurs mostly in the northern region under irrigation systems. The lagged real interest rates are statistically significant, with the expected negative sign. The elasticity is -0.036 for lagged real interest rates on corn harvested area. An intercept dummy variable is used to shift the intercept down for the period 1982-90, which is statistically significant. From 1981 to 1982, corn harvested area decreased from 8.15 million hectares to 6.00 million hectares and did not increase above 6.50 million hectares until 1991. These changes were caused by poor economic conditions beginning in the early 1980s and decreased government subsidies in real terms for the agricultural sector. The coefficient of determination is 0.907, and no autocorrelation is exhibited, with a Durbin-Watson of 2.44.

Corn production in 1,000 metric tons, COSPRMX, is then derived from an identity of corn yield multiplied times corn harvested area in equation 6.4.

Wheat Production

Wheat yield, WHYHAMX, in equation (6.5) is estimated in double-log functional form for the 1975-95 period. The independent variables are real wheat government guaranteed price, a time trend, and two dummy variables, which shift the intercept for 1977-78 and 1991-92. All variables are significant, with the expected signs. Wheat guaranteed price is positive and provides an elasticity of +0.1198, which is consistent with economic theory. As guaranteed price increases, producers will provide increased yields by providing greater inputs, such as fertilizer, pesticides, and irrigation. The time trend is positive and significant. The time trend is used as a proxy for increasing yields due to research in genetics, introduction of new herbicides and pesticides, and development of infrastructure such as irrigation systems. Both of the dummy variables are significant for the two-year time periods of 1977-78 and 1991-92. The dummy variables shift down the intercept for these periods in which a drought occurred or irrigation water from reservoirs was inadequate. Wheat yields in Mexico are among the highest in the world and are highly dependent upon irrigation.

Wheat area harvested, WHAHAMXL, in equation (6.7) is estimated in a double-log functional form for the period 1965-95. The independent variables are real wheat farm price, soybean guaranteed price, rice farm price, sorghum guaranteed price, cotton area harvested, and three intercept shift dummy variables. All the prices are expressed in real terms. The prices are not statistically significant, but they are included for the policy analysis and the simulation results because knowledge of wheat production in Mexico and economic theory suggest that these are important variables in producers' decisions for wheat production. The own-price elasticity for wheat is +0.207, which is consistent with expectations and previous research. The elasticity for soybean price is positive, +0.0645, which is also consistent with expectations and previous research. The coefficient for rice farm price in real terms is restricted to an elasticity of -0.1.

Three intercept shift dummy variables are used in estimating wheat harvested area—1979, 1986, and 1982—which is continued through the estimation period. Only 1979 is significant, but both dummy variables are used to represent a decrease in yields in those three years. The nonsignificant dummy variable is kept because, without this variable, the signs of other relevant variables change. A dummy variable that shifts the intercept up from 1982 on is significant. Beginning in 1982, wheat harvested area was higher on average by 100,000 hectares to 120,000 hectares. The coefficient of determination is 0.77, and no serial correlation is indicated by the Durbin-Watson, which is 1.8.

Rice Production

Rice yield, RIYHAMXL, in equation (6.10) is estimated in double-log functional form for the period 1975-95. All the estimated coefficients are significant and have the expected signs. Yield elasticity with respect to rice farm price is +0.0557, and lagged rice yield is +0.237. Two dummy variables are used, which shift the intercept for different time periods. The first is an intercept shift dummy variable from 1971-83, and the second begins in 1984 and continues through to 1995. Increasing yields were not gradual, but occurred in spurts and then remained relatively constant for a number of years before the next spurt occurred. For example, rice yields averaged 1.75 metric tons per hectare from 1965 to 1974. Then, in 1975, yields increased to 2.24 metric tons per hectare and remained relatively constant, averaging 2.05 metric tons per hectare through 1983. In 1984, yields increased to 2.43 metric tons per hectare and have averaged 2.40 metric tons per hectare to the present. The estimated rice yield has a coefficient of determination of 0.785.

Rice harvested area, RIAHAMXL, in equation (6.11) is estimated as a double-log functional form for the period 1965-95. The independent variables are rice government guaranteed price, wheat farm price in real terms, and three intercept shift dummy variables. The price variables are not significant, but the elasticity rates are within the expected range. The own-price elasticity is +0.1969, and the wheat price elasticity is -0.0782. Wheat and rice are both grown in Sinaloa, the northwest state, and the gulf state of Veracruz, and producers in both states depend on irrigation systems. The intercept is shifted down from 1990 through the rest of estimation and baseline by use of a dummy shift variable. From 1989 to 1990, rice harvested area decreased from 140,000 hectares to 75,000 hectares, and the lower harvested area was maintained through 1997. Two intercept dummy variables are used for the years of 1975 and 1985. During both of these years, the rice harvested area increased. The coefficient of determination is 0.85, and no autocorrelation is exhibited by the Durbin-Watson of 2.53. Rice production is obtained by the identity of yield times area harvested.

Dry Bean Production

The dry bean yield, DBYHAMX, in equation (6.14) is a linear function of dry bean farm price, interest rates, a time trend, and two intercept shift dummy variables. Only the coefficient for dry bean farm price is not statistically significant. The intercept is shifted down for the year 1977 and for the period 1988-89. This shift is due to poor weather conditions within the central region of Mexico because dry beans are quite sensitive to weather conditions. Dry beans are normally not produced under irrigation. The time trend represented increasing yields due to improved varieties and more efficient production.

Dry bean area harvested, DBAHAMXL, in equation (6.15) is a double-log functional form estimated from 1965 to 1995. Area harvested is a function of government guaranteed price, lagged area harvested, and three intercept shift dummy variables. The coefficient for the guaranteed price was imposed as a restriction to be consistent with economic expectations, which is an elasticity of 0.10. The lagged area harvested is not statistically significant. The intercept shifts were used for the years 1979, 1989, and 1992. In all three years, harvested area decreased considerably. Dry bean harvested area is very dependent upon weather conditions. The coefficient of determination is quite low at 0.49. The estimation for dry bean area harvested is among the poorest in the model for area harvested. One possible explanation is that dry beans are consumed mostly by the farm household, indicating that this commodity may not be responsive to market conditions. A second explanation is that the data come from the Government of Mexico and not from the U.S. Department of Agriculture (2000), the source used for the all the other commodities.

Soybean Production

Soybean area harvested, SBAHAMXL, in equation (6.19) is estimated as a double-log functional form over the period 1965-95. All the variables are statistically significant except one: wheat farm price in real terms. The other independent variables are soybean farm price, rice farm price, a time trend, and two intercept shift dummy variables. All prices are expressed in real terms. The signs of the coefficients are consistent with expectations, but own-price elasticity is exceptionally large. Own-price elasticity is 1.226; wheat farm price elasticity is 0.515, and rice farm price elasticity is -0.624. Wheat is expected to have a positive sign because wheat and soybeans are planted in rotation in Mexico. The time trend is used to indicate increasing area harvested from the early 1960s. Poor rain conditions led to wide fluctuations in soybean area harvested from year to year. The intercept dummy shift variables for 1980 and 1988 are used for poor weather conditions. The coefficient of determination is 0.83, and the Durbin-Watson is 1.5, which falls in the indeterminate region for first-order autocorrelation. Soybean production is obtained from yield times area harvested.

Soybeans utilized for crush, SBUCRMX, in equation (6.22) is used to obtain soybean meal and oil. Total supply consists of soybean production, imports, and beginning stocks. Total demand consists of waste and food demand, ending stocks, and soybeans utilized for crush, which is solved for. Soybean meal and oil production are obtained from identities, with conversion ratios of 0.79 and 0.18, respectively.

Sorghum Production

Sorghum yield, SGYHAMX, in equation (6.26) is a linear functional form estimated over the period 1965-95. The independent variables are real sorghum farm price, time trend, lagged interest rates, and three intercept shift variables. All the coefficients are significant except interest rates. All the coefficients have the expected signs. The major variable driving the yield equation is the time trend, which represents modest but consistently increasing yields over the past 30 years, caused by new seed varieties, improved infrastructure for sorghum production, and better management. In Mexico, sorghum yield fluctuates because two-thirds of production is dependent upon weather conditions that affect the available supply of irrigation water.

The sorghum area harvested, SGAHAMXL, in equation (6.27) is estimated over the period 1965 to 1995 in a double-log functional form. The sorghum harvested area is dependent on real sorghum farm price, real corn farm price, and a time trend. The coefficients have the expected signs, although the prices are not statistically significant. The elasticities for area harvested with respect to own price and corn prices are 0.465 and -0.364, respectively. These elasticities are consistent with sorghum production in Mexico because corn is the largest substitute crop for sorghum. A time trend indicates expanding sorghum harvested area in Mexico. The coefficient of determination is 0.6672. The presence of first-order autocorrelation can not be determined, with a Durbin-Watson of 1.46.

Barley Production

Barley yield, BAYHAMX, in equation (6.30) is estimated as a linear function of a time trend over the period 1965-95. The time trend is used as a proxy for increasing yields due to new seed varieties, technology, and management practices. All the coefficients are statistically significant. An intercept shift dummy variable is used for the four-year period 1979-82, when yields were lower. The coefficient of determination is 0.91, and no autocorrelation is indicated by the Durbin-Watson. Barley area harvested, BAAHAMXL, in equation (6.31) is estimated over the period 1965-95, with the real barley government guaranteed price and lagged area harvested as the explanatory variables. Only the barley price is not statistically significant. The coefficient signs are consistent with expectations and provide an elasticity of harvested area with respect to the barley price of 0.109. The intercept shift variable is used for the period 1975-80, during which time area harvested was greater. The coefficient of determination is 0.55.

Estimated Food Consumption Equations

Food consumption of grains is presented in Table 6.3. The food grains are corn, dry beans, wheat, rice, soybean oil, and barely. The equations are estimated with OLS. All food consumption equations are estimated as per capita consumption. Total food consumption is derived from the identity of population times per capita consumption. Only dry beans, rice, barley, and soybean oil are used as food for human consumption. Corn and wheat also have feed demand equations, which are presented.

Corn Consumption

Corn per capita consumption, COUFOKgL, in equation (6.34) is estimated in a double-log functional form over the time period 1975-95. The independent variables are retail prices in real terms for corn, wheat, and dry beans and per capita income. The corn per capita consumption own-price elasticity for retail corn price is -0.0759, the elasticity for wheat retail price is 0.04086, and the dry bean retail price is 0.025934. The elasticities for retail prices are consistent with expected values

Table 6.3 Empirical results of grain food consumption demand

(6.34) Corn consumption per capita in logs (kg/capita)

COUFOkgL = 2.971543 - 0.075944 * log(COPRTMX /CPI85MXe)
(1.89) (-2.61)

+ 0.040861 * log(WHPRTMX /CPI85MXe) + 0.10174 * DM7481
(1.59) (6.18)

+ 0.025934 * log(DBPRTMX /CPI85MXe)+ 0.15699 * log(GDP85PC)
(1.08) (1.43)

Fit over:	1975-1995	R-squared:	0.832	Standard Error:	0.019
LHS Mean:	5.091	Adj. R-squared:	0.776	Durbin-Watson:	1.887

(6.35) Corn consumption per capita (kg/capita)
COUFOPkg = exp(COUFOkgL)

(6.36) Corn consumption (1,000 mt)
COUFOMX = COUFOPkg * DEPOPMX

(6.37) Dry bean consumption in logs (kg/capita)
DBUDCkgL = - 0.064604 * log(DBPFMMX /CPI85MXe) + 0.231797 * log(GDP85PC)
(-0.43) (2.93)

+ 0.722164 * DM81
(3.89)

Fit over:	1975-1995	R-squared:	0.3296	Standard Error:	0.195
LHS Mean:	2.652	Adj. R-squared:	0.2552	Durbin-Watson:	2.375

(6.38) Dry bean consumption per capita (kg/capita)
DBUDCPkg = exp(DBUDCkgL)

(6.39) Dry bean consumption (1,000 mt)
DBUDCMX = DBUDCpkg * DEPOPMX

(6.40) Wheat consumption in logs (kg/capita)
WHUFOkgL = 3.019593 + 0.054053 * log(COPRTMX /WHPRTMX)
(7.48) (1.59)

- 0.046693 * log(RIPRTMX /WHPRTMX) + 0.232617 * lag[log(WHUFOPkg)]
(-0.95) (2.02)

+ 0.016725 * log(DBPRTMX /WHPRTMX) - 0.126533 * DM91 + 0.139984 * DM9394
(0.49) (-4.89) (7.02)

Fit over:	1975-1995	R-squared:	0.8725	Standard Error:	0.025
LHS Mean:	3.856	Adj. R-squared:	0.8178	Durbin-Watson:	

(6.41) Wheat consumption per capita (kg/capita)
WHUFOPkg = exp(WHUFOkgL)

Table 6.3. (continued)

(6.42) Wheat consumption for food (1,000 mt)
WHUFOMX = WHUFOPkg * DEPOPMX

(6.43) Rice consumption in logs (kg/capita)
RIUDCkgL = - 0.150473 * log(RIPRTMX /CPI85MXe)
(-1.52)

+ 0.066558 * log(WHPRTMX /CPI85MXe) - 0.067414 * DM88on
(2.14) (-4.00)

- 0.279593 * Lag[log(RIUDCPkg)] + 0.159395 * log(GDP85PC)
(-1.33) (6.09)

Fit over:	1975-1995	R-squared:	0.4818	Standard Error:	0.027
LHS Mean:	1.694	Adj. R-squared:	0.3522	Durbin-Watson:	

(6.44) Rice consumption per capita (kg/capita)
RIUDCPkg = exp(RIUDCkgL)

(6.45) Rice consumption (1,000 mt)
RIUDCMX = RIUDCPkg * DEPOPMX

(6.46) Rice retail price (pesos/kg)
RIPRTMX = 3,466.44 + 2.494527 * [(RIPFMMX + lag(RIPFMMX)/2)
(0.41) (35.54)

Fit over:	1965-1988	R-squared:	0.9836	Standard Error:	42426
LHS Mean:	7597499	Adj. R-squared:	0.9829	Durbin-Watson:	2.201

(6.47) Barley food consumption in logs (kg/capita)
BAUDCkgL = -0.1045 * log(BAPGAMXe / CPI85MXe) + 0.1834 * log(GDP85PC)
(-1.72) (6.45)

+ 0.043472 * lag(BAUDCkgL) - 0.196275 * (DM82+DM93) + 0.137364 * DM89
(+1.08) (-3.53) (1.77)

Fit over:	1980-1995	R-squared:	0.6191	Standard Error:	0.106
LHS Mean:	1.9085	Adj. R-squared:	0.4805	Durbin-Watson:	na

(6.48) Barley consumption per capita (kg/capita)
BAUDCPkg = exp(BAUDCkgL)

(6.49) Barley consumption (1,000 mt)
BAUDCMX = BAUDCPkg * DEPOPMX

(6.50) Soy oil consumption in logs (kg/capita)
SOUFOkgL = - 0.034232 * log(SOPFOBG /CPI85MXe) + 0.045412 * log(GDP85PC)
(-1.80) (2.71)

+ 0.611180 * lag[log(SOUFOPkg)] + 0.497120 * DM83 - 0.180590 * DM88
(4.24) (3.59) (-1.27)

Table 6.3. (continued)

Fit over:	1975-1995	R-squared:	0.8243	Standard Error:	0.149
LHS Mean:	1.411	Adj. R-squared:	0.7804	Durbin-Watson:	

(6.51) Soy oil consumption per capita (kg/capita)
SOUFOPkg = exp(SOUFOkgL)

(6.52) Soy oil consumption (1,000 mt)
SOUFOMX = SOUFOPkg * DEPOPMX

(6.53) Soybean meal utilization as food and waste (1,000 mt)
SMUFOMX = 0.011791 * SMUDCMX
(7.07)

$u_t = 0.310433\ u_{t-1} + e_t$
(3.07)

Fit over:	1981-1995	R-squared:	0.9763	Standard Error:	2.626
LHS Mean:	22.591	Adj. R-squared:	0.9746	Durbin-Watson:	1.085

(6.54) Soybean meal domestic consumption (1,000 mt)
SMUDCMX = SMUFEMX + SMUFOMX

Variable definitions for food consumption demand:

Endogenous variables:

COUFOkgL:	Corn food per capita consumption in logs (kilograms)
COUFOPkg:	Corn food per capita consumption (kilograms)
COUDCMX:	Corn domestic consumption - as food and feed (1,000 mt)
COUFOMX:	Corn consumption as food for humans (1,000 mt)
COUFEMX:	Corn consumption as feed for livestock (1,000 mt)
WHUFOkgL:	Wheat food per capita consumption in logs (kilograms)
WHUFOPkg:	Wheat food per capita consumption (kilograms)
WHUDCMX:	Wheat domestic consumption - as food and feed (1,000 mt)
WHUFOMX:	Wheat consumption as food for humans (1,000 mt)
WHUFEMX:	Wheat consumption as feed for livestock (1,000 mt)
DBUDCkgL:	Dry bean per capita consumption in logs (kilograms)
DBUDCPkg:	Dry bean per capita consumption (kilograms)
DBUDCMX:	Dry bean domestic consumption as food (1,000 mt)
RIUDCkgL:	Rice per capita consumption in logs (kilograms)
RIUDCPkg:	Rice per capita consumption (kilograms)
RIUDCMX:	Rice domestic consumption (1,000 mt)
RIPRTMX:	Rice retail price (pesos/kg)
BAUDCkgL:	Barley per capita consumption in logs (kilograms)
BAUDCPkg:	Barley per capita consumption (kilograms)
BAUDCMX:	Barley domestic consumption (1,000 mt)
BAPGAMX:	Barley guaranteed price (pesos/kg)
SOUFOkgL:	Soy oil per capita consumption in logs (kilograms)
SOUFOPkg:	Soy oil per capita consumption (kilograms)
SOUFOMX:	Soy oil as food for humans (1,000 mt)
SMUFOMX:	Soybean meal utilized as food and waste (1,000 mt)
SMUDCMX:	Soybean meal domestic consumption (1,000 mt)

Table 6.3. (continued)

Exogenous variables:	
COPRTMX:	Corn retail price (pesos/kg)
WHPRTMX:	Wheat retail price (pesos/kg)
DBPRTMX:	Dry beans retail price (pesos/kg)
DBPFMMX:	Dry beans farm price (pesos/kg)
RIPRTMX:	Rice retail price (pesos/kg)
SOPFOBG:	Soy oil international price f.o.b. gulf (pesos/kg)
CPI85MXe:	Consumer price index in 1985 pesos
GDP85PC:	Gross domestic product per capita in 1985 pesos
DEPOPMX:	Mexico's population
DM81:	Dummy variable: 1 in 1981, 0 otherwise
DM83:	Dummy variable: 1 in 1983, 0 otherwise
DM88:	Dummy variable: 1 in 1988, 0 otherwise
DM91:	Dummy variable: 1 in 1991, 0 otherwise
DM7481:	Dummy variable: 1 in 1974 through 1981, 0 otherwise
DM9394:	Dummy variable: 1 in 1993 through 1994, 0 otherwise
DM88ON:	Dummy variable: 1 beginning in 1988, 0 otherwise

and previous research on Mexico's consumption. The Marshallian elasticity is negative for corn retail price and highly inelastic, which is consistent with a major staple good. Wheat and dry beans are both weak substitutes for corn consumption. The income elasticity is 0.15699, which indicates corn is a normal, or necessary, good. The dummy variable is used to shift the intercept up from 1974 to 1981. Per capita consumption decreased by approximately 20 kilograms from 178 kilograms to 158 kilograms from 1981 to 1982. Per capita consumption of corn was considerably lower through the 1980s, which was most likely caused by the severe economic recession and hyperinflation during that time. Not all of the variables are statistically significant; only corn price and the dummy variable are. The coefficient of determination is 0.83, and no autocorrelation is present, as indicated by the Durbin-Watson.

Dry Bean Consumption

Dry bean per capita consumption, DBUDCKgL, in equation (6.37) is estimated in double-log functional form over the period 1975-95. The explanatory variables are dry bean farm price and per capita income. Both are expressed in real terms, and only income is statistically significant. Dry bean farm price is used as a proxy for retail price, and large on-farm consumption of dry beans lends credibility to this proxy. The estimated own-price elasticity is -0.0646, which is consistent with expectations because there are few substitutes for dry beans and dry beans are considered to be a main staple, although they are not consumed in the same quantities that corn and wheat are consumed. The income elasticity is 0.2317, which seems large because dry beans may actually be an inferior commodity consumed mostly by lower-income consumers. An intercept shift variable, which is significant, was used for 1981 because a large increase in consumption occurred for no apparent reason. In 1981, per capita consumption increased by 6 kilograms, from an average of 16 kilograms. The coefficient of determination is quite low, at 0.32. No first-order autocorrelation is present, as determined by the Durbin-Watson of 2.375. Poor statistical results may be partly due to consumption behavior for dry beans, which are consumed predominantly by farm households. Total domestic consumption is then derived from per capita consumption by multiplying by population.

Wheat Consumption

Wheat per capita consumption, WHUFOKgL, in equation (6.40) is estimated in a double-log functional form over the period 1975-95. Consumption is dependent on the retail prices for corn, rice, and dry beans, which are deflated by the wheat retail price. the own-price elasticity for wheat consumption is -0.024, which is very inelastic and indicates that wheat is major staple with little substitution. In the estimated equation, corn and dry beans are substitutes to wheat, but rice is a complement, which is not consistent with expectations of all three grains being substitutes for wheat. The prices are not statistically significant. The cross-price elasticities for wheat with respect to retail prices are 0.054 for corn, -0.047 for rice, and 0.0167 for dry beans. Two dummy intercept shift variables are used: one is used for 1991, when per capita consumption decreased, and one is used from the two-year period 1993-94, when per capita consumption of wheat increased. The coefficient of determination is 0.87.

Rice Consumption

Rice per capita consumption, RIUDCkgL, in equation (6.43) is estimated in a double-log functional form over the period 1975-95. Consumption is dependent on the retail prices of rice and wheat in real terms, lagged per capita rice consumption, and per capita income. Only wheat price and per capita income are statistically significant. An intercept shift dummy variable is used from 1988 to 1995, which is statistically significant. Prior to 1988, per capita rice consumption averaged 5.55 kilograms, and 1988-95 consumption averaged 5.3 kilograms. Without the intercept shift dummy variable, the coefficients give incorrect signs and are less statistically significant. The rice consumption own-price elasticity is -0.1505, which is consistent with economic expectations, and the cross-price elasticity for wheat retail price is 0.0665, which indicates that wheat is a substitute for rice. The income elasticity is 0.159, which seems reasonable because rice is not considered an inferior or a luxury food in Mexico. The coefficient of determination is 0.48.

Rice retail price, RIPRTMX, in equation (6.46) was estimated as a linear function of rice farm price in nominal terms. Farm price was significant, with a t-ratio of 35.54, and the coefficient of determination, at 0.98, is quite large. The retail price equation provides a simulated retail price for 1988 on because no data were available.

Barley Consumption

Barley per capita consumption, BAUDCkgL, in equation (6.47) is estimated as a double-log functional form over the period 1980-95. Consumption is dependent on government guaranteed price for barley in real terms, which is used as a proxy for the retail, or beer, price because it was unavailable. Consumption is also dependent on lagged per capita barley consumption and per capita income. Only per capita income is statistically significant. Intercept shift dummy variables are used for 1982 and 1993, and for 1989, and both are statistically significant. Without the intercept shift dummy variables, the coefficients give incorrect signs and are less statistically significant. The barley consumption own-price elasticity is -0.104, which is consistent with economic expectations. The income elasticity is 0.18, which seems reasonable because barley (beer) is not considered an inferior or a luxury food in Mexico. The coefficient of determination is 0.62.

Soybean Oil and Meal Consumption

Per capita consumption of soy oil, SOUFOkgL, in equation (6.50) is estimated for the period 1975-95 in a double-log functional form. The independent variables include the border price for soy oil, which is used as a proxy for domestic price; per capita gross domestic product as an income proxy; and lagged soy oil per capita consumption. Soy oil consumption is used mostly for cooking. Most of the variables are statistically significant and have the expected signs. The own-price elasticity is -0.034, and income elasticity is 0.045. Two intercept shift dummy variables are used for 1983 and 1988. The coefficient of determination is 0.82.

Soybean meal utilization as food or waste, SMUFOMX, in equation (6.53) is quite small relative to soybean meal utilized as feed. The soybean meal food equation is a linear function of soybean meal utilized for domestic consumption, SMUDCMX, in equation 6.54, which is soybean meal for feed plus soybean meal for food and waste. The estimation period is 1981-95. The variable soybean meal for domestic consumption is significant at a t-ratio of 7.07 and 0.97 for the coefficient of determination. The Durbin-Watson indicated autocorrelation of the first order, which was accounted for by estimating the equation first differences.

Feed Demand

Four feed demands are presented in Table 6.4. Empirical results of feed demand, which are derived through the ratios of feed consumption to meat production, are called grain consuming production units (GCPUs). A GCPU basically tells us how much feed is required for meat production. The GCPUs are estimated from the period 1975-95 in a semi-log functional form. Feed demand is then derived by an identity of GCPU times meat production. Meat production includes only pork and poultry because most beef production is grass fed. The five feed demands derived are corn, wheat, sorghum, soybean meal, and barley. A feed and waste demand exists for soybeans and soy oil, but these are linear estimations with no price responses incorporated.

Corn

The corn GCPU, COGCPU, in equation (6.55) is estimated as a function of real corn farm price, wheat farm price, soybean government guaranteed price, and lagged corn feed. All the signs are consistent with economic theory to minimize the cost of meat production. As corn prices increase, corn feed usage will decrease. Wheat and soybeans are substitute feeds for corn. The own-price elasticity for corn feed demand is -1.7 and is statistically significant, which is evaluated at the mean. The cross-price elasticities of corn feed demand with respect to wheat prices and soybean meal prices are 0.15 and 0.75, respectively, which are not statistically significant. The corn feed demand is lagged and statistically significant. The coefficient of determination is 0.9284. The corn feed demand results are consistent with the behavior of pork and poultry producers in Mexico because corn utilization as feed is very responsive to market prices and is quickly moved in and out of. Most corn in Mexico is white corn utilized for human consumption, but use of corn for feed has been increasing as the number modern feeding facilities for pork and poultry have increased over the past decade. This result is not similar to the U.S. system, which uses corn primarily as feed and not for human consumption. The corn feed demand is obtained by multiplying the corn GCPU times meat production, which is represented in equation (6.56).

Wheat

Estimated wheat GCPU, WHGCPU, in equation (6.57) depends on real farm prices for wheat, corn, and sorghum, and a time trend. All the coefficients have the expected signs, and all except corn price are statistically significant. The own-price elasticity is -0.43. The wheat feed demand elasticities with respect to corn and sorghum are 0.175 and 0.197, respectively. The coefficient of determination is 0.65, and no autocorrelation is present, as indicated by the Durbin-Watson of 2.3. Wheat is a commodity similar to corn in that most wheat is produced for human consumption and

Table 6.4. Empirical results of feed demand

(6.55) Corn feed grain consumption production units

COGCPU = 7.979694 - 1.902215 * log(COPFMMX/CPI85MXe)
(2.44) (-3.27)

+ 0.172334 * log(WHPFMMX/CPI85MXe)
(0.23)

+ 0.084159 * log(SBPGAMXe /CPI85MXe) + 0.444974 * lag[log(COUFEMX)]
(0.26) (4.34)

Fit over:	1975-1995	R-squared:	0.9284	Standard Error:	0.293
LHS Mean:	1.074	Adj. R-squared:	0.9105	Durbin-Watson:	2.286

(6.56) Corn feed demand (1,000 mt)
COUFEMX = COGCPU * (POSPRMX + PYSPRMX)

(6.57) Wheat feed grain consumption production units
WHGCPU = - 0.325465 * log(WHPFMMX/CPI85MXe)
(-5.33)

+ 0.0551400 * log(COPFMMX/CPI85MXe)
(1.65)

+ 0.0616475 * log(SGPFMMX/CPI85MXe) + 0.382258 * log(TIME)
(2.20) (3.58)

Fit over:	1975-1995	R-squared:	0.6554	Standard Error:	0.131
LHS Mean:	0.301	Adj. R-squared:	0.5946	Durbin-Watson:	2.301

(6.58) Wheat feed demand (1,000 mt)
WHUFEMX = WHGCPU * (POSPRMX + PYSPRMX)

(6.59) Soybean meal feed grain consumption production units
SMGCPU = - 1.197013 + 0.053486 * log(COPFMMX/SBPFMMX)
(-4.66) (0.53)

+ 0.684054 * log(TIME) - 0.062456 * DM8688 + 0.184764 * DM9192
(8.61) (-1.13) (2.65)

Fit over:	1975-1995	R-squared:	0.8790	Standard Error:	0.084
LHS Mean:	0.974	Adj. R-squared:	0.8487	Durbin-Watson:	2.058

(6.60) Soybean meal feed demand (1,000 mt)
SMUFEMX = SMGCPU * (POSPRMX + PYSPRMX)

(6.61) Soybean waste and feed demand (1,000 mt)
SBUFEMX = .025 * SBSTTMX

Table 6.4. (continued)

(6.62) Soybean oil feed and waste demand (1,000 mt)

SOUFEMX = 74.623415 + 11.174274 * log(SOUDCMX) - 38.462854 * log(TIME)
(36.12) (22.47) (-42.22)

$u_t = -0.804522 * u_{t-1} + e_t$
(-7.15)

Fit over:	1984-1995	R-squared:	0.996	Standard Error:	0.394
LHS Mean:	6.864	Adj. R-squared:	0.996	Durbin-Watson:	2.650

(6.63) Sorghum feed grain consumption production units

SGGCPU = -0.523247 * log(SGPFMMX/CPI85MXe)
(-0.93)

+ 0.216053 * log(COPFMMX/CPI85MXe)
(1.02)

+0.189029 * log(SBPGAMXe/CPI85MXe) + 0.375546 * [lag(SGGCPU)]
(0.59) (2.95)

+ 0.952346 * DM81 + 1.419016 * DM91 - 0.665420 * DM94
(2.85) (4.16) (-2.01)

Fit over:	1975-1995	R-squared:	0.8020	Standard Error:	0.314
LHS Mean:	3.766	Adj. R-squared:	0.7172	Durbin-Watson:	1.748

(6.64) Sorghum feed demand (1,000 mt)

SGUDCMX = SGGCPU * (POSPRMX + PYSPRMX)

Variable definitions:

Endogenous variables:

SGGCPU:	Sorghum grain consuming production units
SMGCPU:	Soybean meal grain consuming production units
WHGCPU:	Wheat grain consuming production units
COGCPU:	Corn grain consuming production units
BAGCPU:	Barley grain consuming production units
COUFEMX:	Corn utilized as feed (1,000 mt)
WHUFEMX:	Wheat utilized as feed (1,000 mt)
SMUFEMX:	Soy meal utilized as feed (1,000 mt)
SBUFEMX:	Soybeans utilized as waste and feed (1,000 mt)
SBSTTMX:	Soybean total supply (1,000 mt)
SOUFEMX:	Soybean oil utilized as waste and feed (1,000 mt)
SGUDCMX:	Sorghum utilized as feed (1,000 mt)
POSPRMX:	Pork production (1,000 mt)
PYSPRMX:	Poultry production (1,000 mt)

Exogenous variables:

COPFMMX:	Corn farm price
WHPFMMX:	Sorghum farm price
SBPFMMX:	Soybean farm price

Table 6.4. (continued)

SBPGAMXe:	Soybean government guaranteed price
BAPGAMXe:	Barley government guaranteed price
CPI85MXe:	Consumer price index in 1985 pesos
TIME:	Time trend 1965 = 1 and increases by 1 each year

only when prices are low will it be utilized as feed for pork and poultry. Wheat for feed use has averaged 4 percent to 10 percent of total consumption, except for a few years when this rate increased to 15 percent to 24 percent from 1981 to 1986. This situation accounts for the strong price responsiveness and is similar to that in U.S. cattle feedlots, which will move in and out of wheat use quite quickly as prices change relative to the price of corn.

Soybean Meal

The soybean meal GCPU, SMGCPU, in equation (6.59) depends on corn deflated by the soybean farm price, a time trend, and two dummy variables. Only the time trend and intercept shift dummy variable for 1991 and 1992 are significant. The corn and soybean farm prices have the expected signs but are not statistically significant. The own-price elasticity is not large, at -0.05359, and the elasticity with respect to corn farm price is 0.05359. Soybean meal is the major feed used by Mexico's pork and poultry producers, as indicated by the high inelasticities and low price responsiveness. The coefficient of determination is 0.87, and no autocorrelation is present, as indicated by the Durbin-Watson. Soybean meal feed demand is obtained by multiplying the GCPU by meat production, as shown in equation (6.60).

The soybean waste and feed demand, SBUFEMX, in equation (6.61) is an identity obtained by calculating the ratio of soybean waste and feed demand to total soybean supply, SBSTTMX, which has been consistent at 0.025 and provided good simulation results.

Soybean oil feed and waste demand, SOUFEMX, in equation (6.62) was estimated as a semi-log functional form over the period 1984-95. The independent variables are soybean oil domestic consumption and a time variable. All the coefficients are statistically significant, and serial correlation exists, as indicated by the Durbin-Watson, which was accounted for by estimating the differenced equation. The coefficient of determination is 0.996. Soybean oil for feed and waste is quite small because most is utilized as food consumption and the amount has been decreasing, as indicated by the negative coefficient on the time variable.

Sorghum

The sorghum GCPU, SGGCPU, in equation (6.63) is dependent on sorghum farm price, corn farm price, soybean government guaranteed price, lagged feed demand ratio, and three intercept shift dummy variables. All prices are in real terms, and all coefficients have the expected signs and sizes. The prices are not statistically significant. Own-price elasticity for sorghum feed demand is -0.139, and cross-price elasticities for corn and soybean are 0.075 and 0.050, respectively. The elasticities are quite inelastic, and corn and soybean meal are substitutes to sorghum, as expected. Intercept shift dummy variables are used for years 1981, 1991, and 1994. In 1981 and 1991, feed demand was quite large, and in 1994 it was low. The coefficient of determination is 0.802, and no serial correlation is present, as indicated by the Durbin-Watson. The sorghum feed demand is then obtained by multiplying the sorghum GCPU times meat production, as indicated in equation (6.64).

Total Supply and Utilization, Ending Stocks, and Trade

Table 6.5 presents identities for total supply and utilization, beginning stocks, and imports for the crop sector. Corn beginning stocks, COCITMX, in identity (6.66) is an identity derived from lagged ending stocks, which is set exogenous.

Corn domestic consumption, COUDCMX, in identity (6.67) is corn food consumption plus corn feed demand. Total corn supply, COSTTMX, in identity (6.69) is corn production, imports, and beginning stocks. Total corn utilization, COUTTMX, in identity (6.68) is corn domestic consumption, exports, and ending stocks. Corn net imports, COSMTMX, in identity (6.70) is obtained by solving equilibrium for total supply and total utilization, which closes the corn sector model.

The dry bean identities (6.71) through (6.75) are similar to corn except that equilibrium solves for dry bean imports and exports are exogenous. Dry beans do not have a feed demand; therefore, DBUDCMX is total food consumption in (6.74) DBUTTMX.

The wheat identities (6.76) through (6.81) are the same as corn, with food demand and feed demand, WHUFOMX and WHUFEMX, respectively. Identity (6.81) WHSNMMX solves for wheat net imports and closes the wheat sector model.

The rice identities (6.82) through (6.86) solve for rice beginning stocks, total supply and utilization, and rice net imports. Rice net imports is solved to close the rice sector.

Soybean beginning stocks, total supply and utilization, and imports are presented in identities (6.87) through (6.92). The soybean sector is slightly different because soybean imports, SBSMTMX, in equation (6.91) are estimated as a semi-log functional form over the period 1965-95. The

Table 6.5. Total supply and utilization, ending stocks, and trade

(6.65) Corn ending stocks (1,000 mt)
COCOTMX = 0.10 *COSPRMX

(6.66) Corn beginning stocks (1,000 mt)
COCITMX = lag(COCOTMX)

(6.67) Corn domestic consumption (1,000 mt)
COUDCMX = COUFOMX + COUFEMX

(6.68) Corn total utilization (1,000 mt)
COUTTMX = COUDCMX + COCOTMX + COSMNMX

(6.69) Corn total supply (1,000 mt)
COSTTMX = COSPRMX + COCITMX

(6.70) Corn net imports (1,000 mt)
COSMNMX = COUDCMX + COCOTMX - COSPRMX - COCITMX

(6.71) Dry bean ending stocks (1,000 mt)
DBCOTMX = 0.15 * DBSPRMX

(6.72) Dry bean beginning stocks (1,000 mt)
DBCITMX = lag(DBCOTMX)

(6.73) Dry bean total supply (1,000 mt)
DBSTTMX = DBSPRMX + DBCITMX + DBSMTMX

(6.74)Dry bean total demand (1,000 mt)
DBUTTMX = DBUDCMX + DBCOTMX + DBUXTMX

(6.75) Dry bean net imports
DBSMTMX = DBUDCMX + DBCOTMX + DBUXTMX - DBSPRMX - DBCITMX

(6.76) Wheat ending stocks (1,000 mt)
WHCOTMX = 0.10 * WHSPRMX

(6.77) Beginning wheat stocks (1,000 mt)
WHCITMX = lag(WHCOTMX)

(6.78) Wheat domestic consumption (1,000 mt)
WHUDCMX = WHUFOMX + WHUFEMX

(6.79) Wheat total supply (1,000 mt)
WHSTTMX = WHSPRMX + WHCITMX + WHSNMMX

(6.80) Wheat total demand (1,000 mt)
WHUTTMX = WHUDCMX + WHCOTMX

(6.81) Wheat net imports (1,000 mt)
WHSNMMX = WHUDCMX + WHCOTMX - WHSPRMX – WHCITMX

Table 6.5. (continued)

(6.82) Rice ending stocks (1,000 mt)
RICOTMX = 0.16 * RISPRMX

(6.83) Rice beginning stocks (1,000 mt)
RICITMX = lag(RICOTMX)

(6.84) Rice total supply (1,000 mt)
RISTTMX = RISPRMX + RICITMX + RISMNMX

(6.85) Rice total utilization (1,000 mt)
RIUTTMX = RIUDCMX + RICOTMX

(6.86) Rice net imports (1,000 mt)
RISMNMX = RIUDCMX + RICOTMX - RISPRMX - RICITMX

(6.87) Soybean ending stocks (1,000 mt)
SBCOTMX = 0.07 * SBUDCMX

(6.88) Soybean beginning stocks (1,000 mt)
SBCITMX = lag(SBCOTMX)

(6.89) Soybean total supply (1,000 mt)
SBSTTMX = SBSPRMX + SBCITMX + SBSMTMX

(6.90) Soybean total utilization (1,000 mt)
SBUTTMX = SBUFEMX + SBCOTMX

(6.91) Soybean imports (1,000 mt)
SBSMTMX = 6,153.59 – 1,220.90 * log(SBPGAMXe/CPI85MXe)
(4.25) (-6.15)

+ 958.465496 * log(TIME) + 634.950019 * DM80
(9.53) (2.26)

+ 907.551582 * DM83 - 693.081306 * DM88
(3.21) (-2.36)

Fit over:	1965-1995	R-squared:	0.8991	Standard Error:	273.00
LHS Mean:	1311	Adj. R-squared:	0.8789	Durbin-Watson:	1.85

(6.92) Soybean crush utilization (1,000 mt)
SBUCRMX = SBSPRMX + SBCITMX + SBSMTMX - SBUFEMX - SBCOTMX

(6.93) Soybean meal crush (1,000 mt)
SMSCRMX = SBUCRMX

(6.94) Soybean meal production (1,000 mt)
SMSPRMX = .79 * SMSCRMX

(6.95) Soybean meal beginning stocks
SMCITMX = lag(SMCOTMX)

Table 6.5. (continued)

(6.96) Soybean meal total supply (1,000 mt)
SMSTTMX = SMSPRMX + SMSMTMX + SMCITMX

(6.97) Soybean meal total utilization (1,000 mt)
SMUTTMX = SMUFEMX + SMUFOMX + SMCOTMX

(6.98) Soybean meal imports (1,000 mt)
SMSMTMX = SMUFEMX + SMUFOMX + SMCOTMX - SMSPRMX - SMCITMX

(6.99) Soybean oil production (1,000 mt)
SOSPRMX = .18 * SMSCRMX

(6.100) Soybean oil beginning stocks (1,000 mt)
SOCITMX = lag(SOCOTMX)

(6.101) Soybean oil domestic consumption (1,000 mt)
SOUDCMX = SOUFOMX + SOUFEMX

(6.102) Soybean oil total supply (1,000 mt)
SOSTTMX = SOSPRMX + SOSMTMX + SOCITMX

(6.103) Soybean oil total utilization (1,000 mt)
SOUTTMX = SOUDCMX + SOCOTMX

(6.104) Soybean oil imports (1,000 mt)
SOSMTMX = SOUDCMX + SOCOTMX - SOSPRMX - SOCITMX

(6.105) Sorghum ending stocks (1,000 mt)
SGCOTMX = 0.11 * SGSPRMX

(6.106) Sorghum beginning stocks (1,000 mt)
SGCITMX = lag(SGCOTMX)

(6.107) Sorghum total supply (1,000 mt)
SGSTTMX = SGSPRMX + SGCITMX + SGSMTMX

(6.108) Sorghum total utilization (1,000 mt)
SGUTTMX = SGUDCMX + SGCOTMX

(6.109) Sorghum net imports (1,000 mt)
SGSMNMX = SGUDCMX + SGCOTMX - SGSPRMX - SGCITMX

(6.110) Barley beginning stocks (1,000 mt)
BACITMX = lag(BACOTMX)

(6.111) Barley total supply (1,000 mt)
BASTTMX = BASPRMX + BACITMX + BASMNMX

(6.112) Barley total utilization (1,000 mt)
BAUTTMX = BAUDCMX + BACOTMX

Table 6.5. (continued)

(6.113) Barley imports (1,000 mt)
BASMNMX = BAUDCMX + BACOTMX - BASPRMX - BACITMX

Variable definitions:

Endogenous variables:

COUDCMX:	Corn domestic consumption (1,000 mt)
COUFOMX:	Corn consumption as food (1,000 mt)
COUFEMX:	Corn consumption as feed (1,000 mt)
COSPRMX:	Corn production (1,000 mt)
COSTTMX:	Corn total supply (1,000 mt)
COUTTMX:	Corn total utilization (1,000 mt)
COSMNMX:	Corn net imports (1,000 mt)
COCITMX:	Corn beginning stocks (1,000 mt)
COCOTMX:	Corn ending stocks (1,000 mt)
WHSPRMX:	Wheat production (1,000 mt)
WHUDCMX:	Wheat domestic consumption (1,000 mt)
WHSTTMX:	Wheat total supply (1,000 mt)
WHUTTMX:	Wheat total utilization (1,000 mt)
WHSNMMX:	Wheat net imports (1,000 mt)
WHCITMX:	Wheat beginning stocks (1,000 mt)
WHCOTMX:	Wheat ending stocks (1,000 mt)
DBSPRMX:	Dry bean production (1,000 mt)
DBUDCMX:	Dry bean domestic consumption (1,000 mt)
DBSTTMX:	Dry bean total supply (1,000 mt)
DBUTTMX:	Dry bean total utilization (1,000 mt)
DBSMTMX:	Dry bean imports (1,000 mt)
DBCITMX:	Dry bean beginning stocks (1,000 mt)
DBCOTMX:	Dry bean ending stocks (1,000 mt)
RISPRMX:	Rice milled production (1,000 mt)
RIUDCMX:	Rice domestic consumption (1,000 mt)
RISTTMX:	Rice total supply (1,000 mt)
RIUTTMX:	Rice total utilization (1,000 mt)
RISMNMX:	Rice net imports (1,000 mt)
RICITMX:	Rice beginning stocks (1,000 mt)
RICOTMX:	Rice ending stocks (1,000 mt)
SBUCRMX:	Soybean crush (1,000 mt)
SBUFEMX:	Soybean feed and waste demand (1,000 mt)
SBSPRMX:	Soybean production (1,000 mt)
SBSTTMX:	Soybean total supply (1,000 mt)
SBUTTMX:	Soybean total utilization (1,000 mt)
SBSMTMX:	Soybean imports (1,000 mt)
SBCITMX:	Soybean beginning stocks (1,000 mt)
SBCOTMX:	Soybean ending stocks (1,000 mt)
SMSCRMX:	Soybean meal crush (1,000 mt)
SMUFEMX:	Soybean meal feed consumption (1,000 mt)
SMUFOMX:	Soybean meal food consumption and waste (1,000 mt)
SMSPRMX:	Soybean meal production (1,000 mt)
SMSTTMX:	Soybean meal total supply (1,000 mt)
SMUTTMX:	Soybean meal total utilization (1,000 mt)
SMSMTMX:	Soybean meal imports (1,000 mt)

Table 6.5. (continued)

SOUFEMX:	Soybean oil feed consumption and waste demand (1,000 mt)
SOUFOMX:	Soybean oil food consumption (1,000 mt)
SOSPRMX:	Soybean oil production (1,000 mt)
SOSTTMX:	Soybean oil total supply (1,000 mt)
SOUTTMX:	Soybean oil total utilization (1,000 mt)
SOSMTMX:	Soybean oil imports (1,000 mt)
SGUDCMX:	Sorghum feed consumption (1,000 mt)
SGSPRMX:	Sorghum production (1,000 mt)
SGSTTMX:	Sorghum total supply (1,000 mt)
SGUTTMX:	Sorghum total utilization (1,000 mt)
SGSMNMX:	Sorghum net imports (1,000 mt)
SGCITMX:	Sorghum beginning stocks (1,000 mt)
SGCOTMX:	Sorghum ending stocks (1,000 mt)
BAUDCMX:	Barley feed consumption (1,000 mt)
BASPRMX:	Barley production (1,000 mt)
BASTTMX:	Barley total supply (1,000 mt)
BAUTTMX:	Barley total utilization (1,000 mt)
BASMNMX:	Barley net imports (1,000 mt)
Exogenous variables:	
DBUXTMX	Dry bean exports (1,000 mt)
SMCITMX:	Soybean meal beginning stocks (1,000 mt)
SMCOTMX:	Soybean meal ending stocks (1,000 mt)
SOCITMX:	Soybean oil beginning stocks (1,000 mt)
SOCOTMX:	Soybean oil ending stocks (1,000 mt)
BACITMX:	Barley beginning stocks (1,000 mt)
BACOTMX:	Barley ending stocks (1,000 mt)

independent variables are soybean guaranteed price, a time trend, and the intercept shift dummy variables. All the variables are statistically significant, with the expected signs. The coefficient of determination is 0.89, and the Durbin-Watson is 1.858. Soybean crush, SBUCRMX, is derived from identity (6.92), and not by imports. Mexico has no soybean exports.

Soybean meal crush in identity (6.93) is equal to soybean utilized for crushing. Soybean meal production in identity (6.94) is equal to 79 percent of soybeans available for crushing. In identities (6.95) through (6.98), soybean meal beginning stocks, total supply and utilization, and imports are similar to previous commodities, such as corn and wheat, but stocks are exogenous.

The soybean oil in identity (6.99) is equal to 18 percent of soybeans crushed. In identities (6.100) through (6.104), beginning stocks, domestic consumption, total supply and utilization, and imports are derived. Mexico does not export soybean oil.

Sorghum beginning stocks, total supply and utilization, and imports are derived in identities (6.105) through (6.109), which are similar to those for corn and wheat, except that sorghum has only feed demand. In identity (6.109), sorghum net imports are solved for.

Barley beginning stocks, total supply and utilization, and imports are derived in identities (6.110) through (6.113). Barley stocks are exogenous.

Cattle Supply and Beef Production

Table 6.6 presents empirical results for cattle supply and beef production. The cow herd, CWCITMXL, in equation (6.114) is estimated in a double-log functional form over the period 1975-95 and depends on Mexico's lagged beef carcass price, current and lagged U.S. steer prices for fed cattle, and the lagged cow herd. Most of the signs are consistent with expectations. As cattle prices increase, the cow herd is built up. The cow herd elasticity with respect to carcass live weight price is 0.031; with respect to the current U.S. steer price it is 0.024; with respect to lagged price it is 0.053. The cow herd is lagged, which provides a partial adjustment model.

Cattle death loss, CEUDLMX, in equation (6.117) is a linear function of the total cattle herd and three intercept shift dummy variables estimated over the period 1975-95. All the variables are statistically significant. Approximate death loss averaged 2.6 percent, which seems quite reasonable. The intercept shift dummy variables are used because of unusually high death rates in 1982, 1985, and 1989. The high rates were caused by poor pasture conditions due to drought, of which the most significant occurred in 1982. The coefficient of determination is 0.95 and no serial correlation is present, as indicated by the Durbin-Watson.

Calves born, CVSNBMX, in equation (6.118) is estimated as a linear function dependent upon the number of cows. The coefficient is consistent with expectations of a 55 percent to 65 percent calving rate, which is much lower than the U.S. rate, which averages 80 percent to 90 percent for cow herds. Cow herd is statistically significant. The coefficient of determination is 0.92, and serial correlation was present.

Total cattle slaughtered, CEKTNMXL, in equation (6.119) is estimated in a double-log functional form over the period 1975-95. All variables except Mexico's beef carcass price are statistically significant. Cattle slaughter depends on total cattle herd less the cow herd, lagged cattle slaughter, the beef carcass price, the U.S. fed steer slaughter price, the U.S. sorghum price, and one intercept shift dummy variable for 1989. The coefficients have the expected signs. Elasticity of cattle slaughter with respect to beef carcass price, U.S. fed steer price, and U.S. sorghum price are 0.10, -0.34, and -0.20, respectively. The coefficient of determination is 0.78, and no serial correlation is indicated by the Durbin-Watson of 1.84.

Beef production, BESPRMX, in equation (6.121) is estimated as a linear function of cattle slaughter and time. The coefficient on cattle slaughtered makes sense by converting beef production

Table 6.6. Empirical results for cattle supply and beef production

(6.114) Beef and dairy cows in logs (1,000 head)

CWCOTMXL = 0.031327 * log[lag(BEPCRMXN/CPI85MXe)]
(0.46)

+ 0.023582 * log(STPFMU9 * NIMOMXU9/CPI85MXe)\
(0.49)

+ 0.052598 * log[lag(STPFMU9 * NIMOMXU9/CPI85MXe)]
(1.02)

+ 0.955948 * log[lag(CWCOTMX)]
(44.84)

Fit over:	1975-1995	R-squared:	0.8030	Standard Error:	0.036
LHS Mean:	9.515	Adj. R-squared:	0.7683	Durbin-Watson:	na

(6.115) Cows ending stocks (1,000 head)
CWCOTMX = exp(CWCOTMXL)

(6.116) Cows beginning stocks (1,000 head)
CWCITMX = lag(CWCOTMX)

(6.117) Death loss for all cattle (1,000 head)
CEUDLMX = 0.026008 * lag(CECOTMX) + 1,734.53 * DM82 + 409.563234 * DM85
(32.70) (15.64) (3.70)

+ 464.758474 * DM89
(4.19)

Fit over:	1975-1995	R-squared:	0.9466	Standard Error:	107.44
LHS Mean:	944.39	Adj. R-squared:	0.9372	Durbin-Watson:	2.261

(6.118) Calves born (1,000 head)
CVSNBMX = 0.637816 * CWCITMX
(92.78)

$u_t = 0.583317 * u_{t-1} + e_t$
(3.11)

Fit over:	1975-1995	R-squared:	0.9521	Standard Error:	193.41
LHS Mean:	8630	Adj. R-squared:	0.9496	Durbin-Watson:	1.762

Table 6.6. (continued)

(6.119) Total cattle slaughtered in logs (1,000 head)
CEKTNMXL = 0.729647 * log(CECOTMX-CWCOTMX) + 0.492257 * lag(CEKTNMXL)
(4.36) (4.80)

+ 0.106964 * log(BEPCRMXN/CPI85MXe)
(0.49)

- 0.340171 * log(STPFMU9 *NIMOMXU9/CPI85MXe)
(-2.33)

- 0.200055 * log(SGPGAMXe/CPI85MXe) + 0.373744 * DM89
(-1.92) (3.31)

Fit over:	1975-1995	R-squared:	0.7827	Standard Error:	0.105
LHS Mean:	8.853	Adj. R-squared:	0.7103	Durbin-Watson:	1.847

(6.120) Total cattle slaughtered (1,000 head)
CEKTNMX = exp(CEKTNMXL)

(6.121) Beef production (1,000 mt)
BESPRMX = -31,189.37 + 0.169588 * CEKTNMX + 15.825708 * TIME
(-4.16) (10.22) (4.15)

Fit over:	1975-1995	R-squared:	0.9603	Standard Error:	69.241
LHS Mean:	1448	Adj. R-squared:	0.9558	Durbin-Watson:	1.695

(6.122) Beef net imports (1,000 mt)
BESMNMX = BEUDCMX - BESPRMX

(6.123) Cattle exported (1,000 head)
CETXNMX = - 418.737016 * log(COPOBU9 * NIMOMXU9/CPI85MXe)
(-1.14)

+ 553.563677 * log(STPFMU9 * NIMOMXU9/CPI85MXe)
(1.27)

+ 0.520505 * lag(CETXNMX)
(2.06)

Fit over:	1975-1995	R-squared:	0.3097	Standard Error:	36.560
LHS Mean:	695.087	Adj. R-squared:	0.2330	Durbin-Watson:	1.755

(6.124) Cattle herd for beef and dairy, ending and beginning herds (1,000 head)
CECOTMX = CECITMX + CVSNBMX - CEKTNMX - CEUDLMX - CETXNMX

(6.125) Cattle herd ending stocks (1,000 head)
CECITMX = lag(CECOTMX)

Table 6.6. (continued)

Variable definitions and units:

Endogenous variables:	
CWCOTMX:	Beef and dairy cow herd (1,000 head)
CEUDLMX:	Cattle death loss (1,000 head)
CECOTMX:	Cattle inventory ending stocks (1,000 head)
CECITMX:	Cattle inventory beginning stocks (1,000 head)
CVSNBMX:	Calves born (1,000 head)
CEKTNMX:	Total slaughter (1,000 head)
BESPRMX:	Beef production (1,000 metric tons)
BETMNMX:	Beef net imports (1,000 metric tons)
CETXNMX:	Net cattle exports (1,000 head)
Exogenous variables:	
BEPCRMXN:	Beef carcass price at farm (pesos/kg)
CHPLWMXN:	Poultry price live weight birds (pesos/kg)
CPI85MXe:	Consumer price index in 1985 pesos
GDP85PC:	Gross domestic product per capita in 1985 pesos
STPFMU9:	United States fed steer price (U.S. $/cwt)
NIMOMXU9:	Exchange rate pesos to U.S. dollar
DM82:	Dummy variable 1 in 1982 0 other
DM85:	Dummy variable 1 in 1985 0 other
DM89:	Dummy variable 1 in 1989 0 other
TIME:	Time trend 1965 = 1

to kilograms and cattle slaughter to one head; then, a one-head increase in slaughter increases beef production by 169.58 kilograms, or 374 pounds. The results seem reasonable; for example, a fed heifer in the United States weighing 1,050 pounds with a yield of 63 percent would produce 661.5 pounds of meat. Cattle in Mexico are much lighter and have a lower yield, plus the above equation includes all slaughtered cattle, which includes calves and cows. The time trend is included because the average carcass weight of cattle and yields have been increasing with respect to time in Mexico, due to improved breeds, management, and feeding practices. The coefficient of determination is 0.96, and no serial correlation is indicated by the Durbin-Watson.

Beef net imports, BESMNMX, in equation (6.122) are solved by the identity. Mexico's cattle net exports, CETXNMX, in equation (6.123) are estimated as a linear function of U.S. corn price, U.S. fed steer price, and lagged cattle exports over the period 1975-95. All the variables have the expected signs. Cattle from Mexico is mostly determined by the profitability of fed cattle operations in the United States. As corn prices decrease or fed cattle prices increase, feedlot managers and backgrounders are willing to pay a higher price for feeder cattle, which increases exports of Mexican feeder cattle. The coefficient of determination is 0.31, and no serial correlation is present.

Hogs and Pig Supply and Pork Production

Table 6.7 presents pork production and the supply of hogs and pigs. The sow ending inventory, SWCOTMX, in equation (6.126) is estimated as a linear function of pork carcass price, soybean farm price, lagged interest rates, and a lagged dependent variable over the period 1975-95.

The variables have the expected signs, but only the lagged sow ending inventory is statistically significant. As pork carcass price increases, the sow inventory increases, and as cost of feed increases, inventory decreases, as indicated by soybean price and interest rates. The coefficient of determination is 0.41.

The number of pigs born, PGSNBMX, in equation (6.128) is estimated as a linear function of sow beginning stocks over the period 1975-95. The coefficients have the expected signs and are statistically significant. The coefficient for sow ending stocks indicates that, on average, 15.9 pigs are born per sow per year, which is consistent with biological expectations. The correlation of determination is 0.89 and serial correlation was present, with a Durbin-Watson of 0.84 prior to correction.

Hogs and pigs slaughtered, HPKTNMX, in equation (6.129) is a linear function of pigs born lagged one and two years, pork carcass price, and soybean price over the period 1975-95. Most of variables are statistically significant and the signs are consistent with expectations. Slaughter increases as the number of pigs increases, and slaughter decreases with an increase in the pork carcass price, which may due to the building of the sow inventory. As soybean price increases, slaughter increases because of the increased cost of feeding pigs. The coefficient of determination is 0.66, and serial correlation is indeterminate.

Pork production, POSPRMX, in equation (6.130) is estimated as a linear function of hogs and pigs slaughtered over the period 1975-95. The coefficient is statistically significant and indicates that, on average, for every hog and pig slaughtered, 72.085 kilograms, or 159 pounds, of meat are produced. The coefficient of determination is 0.79 and serial correlation was present, with an initial Durbin-Watson at 1.17, but the statistical test on the autoregressive coefficient is not significant, at -0.27, after correction for autocorrelation.

Poultry Production

Poultry production and trade are presented in Table 6.8 and consist of production, imports, and domestic consumption. Poultry meat production, PYSPRMXL, in equation (6.132) is estimated as a linear double-log function of a lagged dependent variable, soybean farm price, sorghum farm price, and poultry live weight carcass price over the period 1975-95. Only lagged poultry production is

Table 6.7. Empirical results for hog and pig supply and pork production

(6.126) Sow ending inventory (1,000 head)

SWCOTMX = 259.950889 + 0.651627 * lag(SWCOTMX)
(1.53) (3.94)

+ 12.800523 * lag(POPCRMXN/CPI85MXe) - 0.015631 * lag(NIINTRMX)
(1.35) (-0.30)

- 0.131076 * (SBPFOBG * NIMOMXU9/CPI85MXe)
(-0.14)

Fit over:	1975-1995	R-squared:	0.5311	Standard Error:	45.380
LHS Mean:	614.409	Adj. R-squared:	0.4139	Durbin-Watson:	na

(6.127) Sow beginning stocks (1,000 head)

SWCITMX = lag(SWCOTMX)

(6.128) Pigs born (1,000 piglets)

PGSNBMX = 15.789614 * (SWCITMX) + 457.985348 * DM83
(69.77) (1.91)

$u_t = 0.744941 * u_{t-1} + e_t$
(4.47)

Fit over:	1975-1995	R-squared:	0.9433	Standard Error:	296.23
LHS Mean:	14522	Adj. R-squared:	0.9370	Durbin-Watson:	1.822

(6.129) Hog and pig slaughter (1,000 head)

HPKTNMX = 7,723.92 + 0.473940 * [PGSNBMX/2+lag(PGSNBMX/2)]
(3.02) (3.67)

- 668.690556 * (POPCRMXN/CPI85MXe)
(-2.49)

+ 1.804384 * (SBPFOBG *SBTARF* NIMOMXU9/CPI85MXe)
(1.47)

Fit over:	1975-1995	R-squared:	0.6642	Standard Error:	1116.68
LHS Mean:	12114	Adj. R-squared:	0.6049	Durbin-Watson:	1.55

(6.130) Pork production (1,000 mt)

POSPRMX = 0.072085 * HPKTNMX
(89.70)

$u_t = -0.0627 * u_{t-1} + e_t$
(-0.27)

Fit over:	1975-1995	R-squared:	0.7967	Standard Error:	47.67
LHS Mean:	876.65	Adj. R-squared:	0.7860	Durbin-Watson:	1.06

Table 6.7. (continued)

(6.131) Net pork imports (1,000 mt)
POSMNMX = POUDCMX - POSPRMX

Variable definitions and units:

Endogenous variables:	
SWCOTMX:	Sows ending stocks (1,000 head)
SWCITMX:	Sows beginning stocks (1,000 head)
PGSNBMX:	Number of pigs born (1,000 head)
HPKTNMX:	Hogs and pigs slaughtered (1,000 head)
POSPRMX:	Pork production (1,000 metric tons)
POUDCPkL:	Pork per capita consumption in logs (kg/capita)
POUDCPkg:	Pork per capita consumption (kg/capita)
POUDCMX:	Pork domestic consumption (1,000 metric tons)
POSMNMX:	Pork net imports (1,000 metric tons)
Exogenous variables:	
POPCRMXN:	Pork carcass price in Mexico (pesos/kg)
BGP7MU9:	U.S. price of barrow and gilts in 7 market (U.S. $/cwt.)
SBPFOBG:	U.S. Soybean f.o.b. price for exports
NIINTRMX:	Real interest rate for Mexico
NIMOMXU9:	Exchange rate for Mexico pesos to U.S. dollars
CPI85MXe:	Consumer price index base is 1985
POTARF:	Tariff on pork imports
SBTARF:	Tariff on soybean imports
TIME:	Time trend beginning in 1965 = 1 and increases by 1 each year thereafter

statistically significant. The coefficient of determination is 0.95. The elasticities obtained from the double-log functional forms seem appropriate. Elasticities for poultry meat production with respect to soybean farm price, sorghum farm price, and poultry live weight price are -0.24, -0.13, and 0.103, respectively. Poultry imports are derived from domestic consumption minus production. The model is relatively simple but should provide feedback to feed demand equations.

Meat Demand for Beef, Pork, and Poultry

Table 6.9 presents estimation of meat demand for beef, pork, and poultry. Per capita beef consumption, BEUDCPKL, in equation (6.136) is estimated as a double-log functional form over the period 1975-95. Meat consumption depends on beef carcass price and pork carcass price, per capita income, lagged per capita beef consumption, and intercept shift variables for (1977 + 1978 + 1986 + 1987). Most of the variables are statistically significant, but price is not. The coefficients had the expected signs. The own-price elasticity for per capita beef consumption is -0.306, and the cross-price elasticity for pork is 0.236. Pork is a substitute for beef. The pork elasticity seems reasonable, but the poultry elasticity was quite large, which may cause problems in policy analysis, so it was not incorporated because the substitution effect was twice its own-price effect in beef. The income elasticity is 0.13, indicating that beef is a normal good; therefore, as income increases by 1 percent, beef consumption will increase by 0.13 percent. Lagged per capita beef consumption is positive. The coefficient of determination is 0.659. Total beef consumption, BEUDCMX, is obtained in equation (6.138) by multiplying per capita beef consumption by population.

Table 6.8. Empirical results for poultry production and trade

(6.132) Poultry production in logs (1,000 mt)

PYSPRMXL = 2.432894 + 0.8174 * lag(PYSPRMX L)
(1.14) (4.13)

- 0.2424296 * log(SBPFMMX/CPI85MXe) - 0.128804 * log(SGPFMMX/CPI85MXe)
(-1.62) (-0.64)

+ 0.103069 *log(CHPLWMXN/CPI85MXe) - 0.108016 * (DM83 + DM87)
(0.89) (-1.34)

Fit over:	1975-1995	R-squared:	0.9566	Standard Error:	1.013
LHS Mean:	6.449	Adj. R-squared:	0.9421	Durbin-Watson:	1.468

(6.133) Poultry production (1,000 mt)

PYSPRMX_ = exp(PYSPRMXL)

(6.134) Poultry imports (1,000 mt)

PYSMTMX = PYUDCMX - PYSPRMX

(6.135) Poultry domestic consumption (1,000 mt)

PYUDCMX = PYUDCPkg * DEPOPMX

Variable definitions and units:

Endogenous variables:

PYSPRMX:	Poultry meat production (1,000 mt)
PYSMTMX:	Poultry meat imported (1,000 mt)
PYUDCMX:	Poultry meat consumption (1,000 mt)

Exogenous variables:

CHPLWMXN:	Poultry live weight price (pesos/kg)
SGPFMMX:	Sorghum farm price (pesos/mt)
SBPFMMX:	Soybean farm price (pesos/mt)
CPI85MXe:	Consumer price index in 1985 pesos
DM87:	Dummy variable: 1 in 1988 0 otherwise
DM83:	Dummy variable: 1 in 1983 0 otherwise

Table 6.9. Empirical results of meat demand for beef, pork, and poultry

(6.136) Beef per capita consumption in logs (kg/capita)
BEUDCPkL = -0.306 * log(BEPCRMXN /CPI85MXe)
(-1.22)

+ 0.23625 * log(POPCRMXN /CPI85MXe) + 0.43981 * log[lag(BEUDCPkg)]
(1.71) (3.12)

+ 0.135214 * log(GDP85PC) - 0.221773 * (DM77+DM78+DM86+DM87)
(3.05) (-3.63)

Fit over:	1975-1995	R-squared:	0.6594	Standard Error:	0.106
LHS Mean:	2.908	Adj. R-squared:	0.5743		

(6.137) Beef per capita consumption (kg/capita)
BEUDCPkg = exp(BEUDCPkL)

(6.138) Beef consumption (1,000 mt)
BEUDCMX = BEUDCPkg * DEPOPMX

(6.139) Pork per capita consumption in logs (kg/capita)
POUDCPkL = - 0.373241 * log(POPCRMXN / CHPLWMXN) + 0.163169 * log(GDP85PC)
(-3.44) (4.37)

+ 0.162328 * lag(POUDCPkl) - 0.175658 * (DM77 +DM90) - 0.129169 * DM85
(-3.66) (-1.92)

Fit over:	1975-1995	R-squared:	0.7977	Standard Error:	0.086
LHS Mean:	2.434	Adj. R-squared:	0.7472		

(6.140) Pork per capita consumption (kg/capita)
POUDCPkg = exp(POUDCPkL)

(6.141) Pork consumption (1,000 mt)
POUDCMX = POUDCPkg * DEPOPMX

(6.142) Poultry per capita consumption in logs (kg/capita)
PYUDCPkL = - 9.697825 + 0.24568 * log(POPCRMXN /CPI85MXe)
(-2.37) (2.05)

- 0.372506 * log(CHPLWMXN /CPI85MXe) + 0.734845 * lag(PYUDCPkL)
(-3.02) (5.97)

+ 0.786518 * log(GDP85PC) - 0.240058 * DM87
(2.61) (-2.86)

Fit over:	1975-1995	R-squared:	0.9495	Standard Error:	0.096
LHS Mean:	2.153	Adj. R-squared:	0.9327		

(6.143) Poultry per capita consumption (kg/capita)
PYUDCPkG = exp(PYUDCPkL)

Table 6.9. (continued)

(6.146) Poultry consumption (1,000 mt)
PYUDCMX = PYUDCPkg * DEPOPMX

Variable definitions for food consumption demand:

Endogenous variables:	
BEUDCPkgL:	Beef per capita consumption in logs (kilograms)
BEUDCPkg:	Beef per capita consumption (kilograms)
BEUDCMX:	Beef domestic consumption (1,000 mt)
POUDCPkgL:	Pork per capita consumption in logs (kilograms)
POUDCPkg:	Pork per capita consumption (kilograms)
POUDCPMX:	Pork per domestic consumption (1,000 mt)
PYUDCPkgL:	Poultry per capita consumption in logs (kilograms)
PYUDCPkg:	Poultry per capita consumption (kilograms)
PYUDCMX:	Poultry domestic consumption (1,000 mt)
Exogenous variables:	
BEPCRMXN:	Beef carcass price at farm (pesos/100 kilograms)
CHPLWMXN:	Poultry live weight price at farm (pesos/100 kilograms)
POPCRMXN:	Pork carcass price at farm (pesos/100 kilograms)
STPFMU9:	U.S. Omaha choice steer price (U.S. $/cwt.)
BETARF:	Tariff
NIMOMXU9:	Exchange rate (pesos per U.S. dollar)
CPI85MXe:	Consumer price index in 1985 pesos
GDP85PC:	Gross domestic product per capita in 1985 pesos (1,000 pesos)
DEPOPMX:	Population of Mexico (million people)

Pork per capita consumption, POUDCPKL, in equation (6.139) is estimated as a double-log functional form and as a function of pork carcass price, poultry live weight price, lagged per capita consumption, and per capita income over the period 1975-95. All the variables are statistically significant. The own-price elasticity for pork consumption is -0.37 and the cross-price elasticity for poultry is 0.37. The sign and size are reasonable, except that the cross-price elasticity is the same size as own-price elasticity. Income elasticity is 0.16, which indicates that pork is a normal good. The coefficient of determination is 0.79.

Poultry per capita consumption, PYUDCPKL, in equation (6.142) is a double-log functional form estimated over the period 1975-95. Poultry per capita consumption is based on pork carcass price and poultry price in real terms, per capita income, and lagged per capita poultry consumption. All the variables are significant. The own-price elasticity is -0.37, and the pork cross-price elasticity is 0.24, both of which seem reasonable. The poultry income elasticity is 0.78. The coefficient of determination is 0.94.

Model Elasticities

Elasticities for the Mexico agricultural model are presented in Tables 6.10 through 6.14. The elasticities are discussed in the text with the explanation of the estimated equations. These tables are provided for easy comparison and access. Most of the elasticities exhibit the right signs and provide reasonable response.

Table 6.10. Elasticities for crop supply response in yields

	Farm Prices or Government Guaranteed Prices						
Yields	Corn	Wheat	Dry Beans	Rice	Sorghum	Soybean	Barley
Corn	—	—	—	—	—	—	—
Wheat	—	0.120	—	—	—	—	—
Dry beans	—	—	0.000014	—	—	—	—
Rice	—	—	—	0.056	—	—	—
Sorghum	—	—	—	—	0.0006	—	—
Soybeans	—	—	—	—	—	—	—
Barley	—	—	—	—	—	—	—

Table 6.11. Elasticities for crop supply response in area harvested

	Farm prices or government guaranteed prices						
Area harvested	Corn	Wheat	Dry Beans	Rice	Sorghum	Soybeans	Barley
Corn	0.196	—	0.024	—	-0.168	—	—
Wheat	—	0.207	—	-0.100	-0.057	0.064	—
Dry beans	—	—	0.100	—	—	—	—
Rice	—	-0.078	—	0.197	—	—	—
Sorghum	-0.365	—	—	—	0.465	—	—
Soybean	—	0.515	—	-0.624	—	1.226	—
Barley	—	—	—	—	—	—	0.109

Table 6.12. Grain food consumption price and income elasticities

	Retail Prices					
	Corn	Wheat	Dry Beans	Rice	Soybean Oil	Income
Corn	-0.0759	0.0408	0.0259	—	—	0.1569
Wheat	0.0541	-0.0242	0.0167	-0.0467	—	—
Dry beans	—	—	-0.0646	—	—	0.2318
Rice	—	0.0665	—	- 0.0505	—	0.1594
Soy oil	—	—	—	—	- 0.0342	0.0454

Table 6.13. Meat consumption price and income elasticities

	Beef	Pork	Poultry	Income
Beef	- 0.306	0.236	—	0.145
Pork	—	- 0.373	0.373	0.163
Poultry	—	0.248	- 0.372	0.734

Table 6.14. Grain feed demand price elasticities

	Farm Prices or Government Guaranteed Prices			
Commodity	Corn	Wheat	Sorghum	Soybean Meal
Corn	-1.700	0.154	—	0.075
Wheat	—	-0.423	0.197	—
Sorghum	0.075	—	-0.139	0.050
Soybean meal	0.054	—	—	-0.054

Alternative Specifications

A number of alternative functional forms were estimated for the grain and food demand equations for the Mexico model. The estimated parameters from these functional forms are often not the expected sign or size, as suggested by economic theory for food consumption in Mexico. The estimated parameters are quite sensitive to functional form and choice variables, even though economic theory suggests which variables should be included. The statistical significance of the variables is usually quite low. These functional forms have been applied in modeling numerous other countries with satisfactory results.

The demand function initially estimated is a popular functional form that satisfies the properties of demand systems, or the AIDS (Deaton and Muellbauer 1980). The properties satisfied include homogeneity, adding up, and symmetry. Additional demand systems estimated included a double-logarithmic demand system incorporating Stone's price index, which satisfies properties of adding up and homogeneity. A double-logarithmic demand system not incorporating Stone's price index, but satisfying homogeneity restrictions, was also estimated. All the demand systems provided unsatisfactory results with respect to price and income elasticities.

Table 6.15 provides the estimated Linear AIDS (LAIDS) model, and Table 6.16 presents elasticities from the estimated demand system. The variables in the poultry equation (6.147) are not statistically significant, and the coefficients do not have the expected signs. The elasticities in Table 6.16 exhibit the wrong signs and sizes. The pork demand share is given in equation (6.147) and the beef demand share is given in identity (6.148).

Table 6.15. Linear Almost Ideal Demand System

(6.147) Poultry demand

PYS = 0.254345 + 0.00349947 * PYPLWkL - 0.055069 * POPCRkL
(1.02) (0.12) (-1.72)

+ [-0.00349947 - (-0.055069)] * BEPCRkL - 0.019834 * INDEXk
(0.12) (-1.72) (-0.29)

Fit over:	1975-1995	R-squared:	0.3756
DW:	1.122	Adj. R-squared:	0.2809

(6.147) Pork demand

POS = 1.173309 - 0.055069 * PYPLWkL + 0.250033 * POPCRkL
(3.12) (-1.72) (3.27)

+ [- (-0.055069) - 0.250033] * BEPCRkL - 0.238189 * INDEXk
(-1.72) (3.27) (-2.31)

$u_t = 0.63596 * u_{t-1} + e_t$
(-3.02)

Fit over:	1975-1995	R-squared:	0.7331
DW:	1.683	Adj. R-squared:	0.6728

(6.148) Beef demand

BES = 1 - PYS - POS

Variable definitions for food consumption demand:

Endogenous variables:

PYS:	Poultry expenditure share
POS:	Pork expenditure share
BES	Beef expenditure share

Exogenous variables:

INDEXk	Stone's price index
PYPLWkL	Poultry price in logs (pesos/kg)
POPCRkL	Pork price in logs (pesos/kg)
BEPCRkL	Beef price in logs (pesos/kg)

Table 6.16. Elasticities Linear Almost Ideal Demand System

	Beef	Pork	Poultry	Income
	-------Marshallian Elasticities------			
Beef	-1.593	1.163	0.032	0.396
Pork	-0.252	-0.548	0.004	0.796
Poultry	0.169	-0.125	-0.966	0.922
	--------Hicksian Elasticities--------			
Beef	-1.762	—	—	—
Pork	-0.593	0.386	—	—
Poultry	-0.224	0.956	-0.731	—

Simulation Statistics

Simulation statistics are obtained for the period 1975-95 to validate the performance of this model. The statistics used for validation are root mean squared error (RMSE), root mean squared percent error (RMSPE), and decomposition of Theil statistics into three proportions, which include bias (BIAS), variance (VAR), and covariance (COVAR). Table 6.17 presents the dynamic simulation statistics.

The RMSE is a measurement of the deviation simulated value from the actual value, which is then compared to the mean value of the actual variable. The smaller the deviation, the smaller the RMSE is relative to the mean. However, this can be misleading when variables such as net imports occasionally take on negative values; when this happens, the mean will be lower. A good example of this is dry bean imports, which has negative net imports for a number of years during the simulation. Soybean oil imports also perform quite poorly because imports close the model and production and consumption are quite large, with imports accounting for the difference. Therefore, soybean oil production and consumption may simulate quite well with little deviation from the mean, yet imports will have very large deviations.

The RMSPE is a measure of deviation of the simulated value from its actual value, expressed in percentage terms. A value of 10 percent or less usually indicates that the model is simulating quite well for that variable. However, there are a few cases where the value is very large; for example, the dry bean net imports value is 897 and the wheat net imports value is 410. This occurs because net imports are close to zero in some years.

The Theil statistics are decomposed into three parts, and no aggregate Theil statistic is given. The first part, listed in Table 6.17, is the bias proportion. This is the proportion of the simulation error which is attributable to the difference between the mean of the actual and the average value of the simulated variable. A large value indicates a systematic error within the model, which indicates under- or over-estimating the variable systematically.

The second Theil statistic is the variance proportion, which is the measurement between the variance of the simulated variable and the variance of the actual value. The variance proportion provides an indication of how well the model is able to replicate the degree of variability in the variable modeled. If the Theil variance proportion is large, the estimated variable may not fluctuate a lot, whereas the actual data do, or vice versa. The smaller the Theil variance statistic, the better fitting the simulation model.

The third Theil statistic is the covariance proportion, which measures the unsystematic error of the simulated variable. This statistic measures the remaining error after deviations from the average values and average fluctuations have been accounted for. The covariance proportion statistic ranges from 0 to 1, with 1 being a perfect simulation because all the bias and variance would be accounted for and equal to 0.

Table 6.17. Dynamic simulation statistics for the period

Variable	Mean	RMS Error	RMS % Error	Theil Statistics Bias	Variance	Covar.
COYHAMX	1.66	0.12	6.86	0.000	0.024	0.976
DBYHAMX	0.60	0.05	7.94	0.002	0.030	0.968
WHYHAMX	3.84	0.20	4.68	0.008	0.014	0.978
WHYHAMXL	1.34	0.05	3.40	0.007	0.012	0.981
RIYHAMX	2.37	0.22	10.17	0.004	0.186	0.811
SGYHAMX	2.91	0.11	3.99	0.009	0.053	0.937
BAYHAMX	1.65	0.08	5.14	0.011	0.000	0.989
COAHAMX	7136.00	259.86	3.73	0.002	0.017	0.981
WHAHAMX	883.10	53.69	6.01	0.008	0.033	0.958
DBAHAMX	1705.00	181.81	11.52	0.022	0.047	0.931
RIAHAMX	130.57	17.09	15.96	0.007	0.022	0.971
SGAHAMX	1221.00	203.10	16.89	0.001	0.152	0.847
SBAHAMX	297.00	59.53	25.07	0.027	0.000	0.973
BAAHAMX	263.52	24.38	8.71	0.114	0.010	0.876
COAHAMXL	8.86	0.04	0.41	0.004	0.012	0.984
WHAHAMXL	6.78	0.06	0.89	0.005	0.030	0.965
DBAHAMXL	7.43	0.11	1.45	0.033	0.039	0.927
RIAHAMXL	4.80	0.15	3.30	0.016	0.021	0.964
SGAHAMXL	7.10	0.16	2.30	0.007	0.148	0.845
SBAHAMXL	5.64	0.23	4.26	0.024	0.004	0.971
BAAHAMXL	5.57	0.09	1.63	0.113	0.010	0.877
COSPRMX	11843.00	991.16	8.11	0.000	0.037	0.963
WHSPRMX	3416.00	308.38	8.49	0.016	0.048	0.936
DBSPRMX	1024.00	131.55	13.95	0.006	0.076	0.917
RISPRMX	300.86	43.94	17.23	0.008	0.025	0.967
SGSPRMX	3568.00	675.77	18.76	0.000	0.121	0.879
BASPRMX	431.90	46.53	10.27	0.136	0.189	0.675
SBSPRMX	548.38	107.83	25.06	0.015	0.001	0.984
SMSPRMX	1361.00	196.46	14.93	0.004	0.030	0.966
SOSPRMX	295.90	45.87	17.14	0.136	0.000	0.863
SBSCRMX	1735.00	245.32	14.45	0.000	0.032	0.967
SMSCRMX	1735.00	245.32	14.45	0.000	0.032	0.967
COUFOKGL	5.09	0.02	0.33	0.000	0.063	0.937
WHUFOKGL	3.86	0.02	0.53	0.000	0.049	0.951
DBUFOKGL	2.65	0.18	6.93	0.000	0.120	0.880
RIUFOKGL	1.69	0.02	1.42	0.000	0.129	0.870
SOUFOKGL	1.40	0.17	14.29	0.000	0.129	0.871

Table 6.17. (continued)

Variable	Mean	RMS Error	RMS % Error	Theil Statistics Bias	Variance	Covar.
COUFOPKG	162.83	2.72	1.68	0.000	0.060	0.940
WHUFOPKG	47.31	0.96	2.06	0.001	0.055	0.944
DBUDCPKG	14.55	2.62	18.22	0.003	0.009	0.988
RIUDCPKG	5.45	0.14	2.41	0.001	0.137	0.863
SOUFOPKG	4.24	0.67	16.26	0.013	0.094	0.894
COUFOMX	12518.00	223.95	1.68	0.000	0.039	0.961
WHUFOMX	3647.00	76.15	2.06	0.000	0.003	0.996
DBUDCMX	1117.00	191.45	18.22	0.002	0.009	0.988
RIUDCMX	418.86	9.08	2.41	0.001	0.008	0.992
SOUFOMX	335.48	51.66	16.26	0.014	0.054	0.932
SMUFOMX	21.76	3.31	.	0.032	0.019	0.950
COGCPU	0.93	0.43	180.54	0.194	0.085	0.721
WHGCPU	0.31	0.12	83.85	0.000	0.108	0.892
SMGCPU	0.96	0.07	9.94	0.000	0.034	0.966
SGGCPU	3.77	0.27	7.02	0.000	0.190	0.810
COUFEMX	1699.00	716.31	189.96	0.074	0.277	0.649
WHUFEMX	475.90	214.28	103.36	0.000	0.096	0.904
SGUDCMX	5729.00	460.18	8.84	0.002	0.024	0.974
SMUFEMX	1526.00	139.04	9.14	0.013	0.003	0.984
SBUFEMX	52.95	29.17	30.96	0.021	0.534	0.445
SOUFEMX	6.81	1.33	.	0.007	0.003	0.990
COUDCMX	14217.00	789.26	5.57	0.058	0.178	0.764
WHUDCMX	4123.00	216.62	5.13	0.000	0.019	0.980
SMUDCMX	1548.00	139.75	9.08	0.014	0.003	0.983
SOUDCMX	342.29	52.51	16.25	0.013	0.047	0.940
BAUDCMX	515.86	45.51	8.64	0.000	0.008	0.992
COSMTMX	2491.00	1120.00	105.49	0.030	0.022	0.949
WHSNMTMX	707.86	339.63	410.31	0.014	0.001	0.985
DBSMTMX	94.33	232.28	897.45	0.007	0.336	0.657
RISMNMX	119.95	43.47	.	0.010	0.000	0.990
SGSMU9MX	2038.00	772.89	75.57	0.000	0.053	0.947
SGSMNMX	2170.00	711.25	49.56	0.001	0.064	0.936
SBSMTMX	1247.00	271.86	58.13	0.003	0.096	0.901
SMSMTMX	193.86	211.24	.	0.018	0.419	0.563
SMSTTMX	1706.00	139.75	8.16	0.014	0.001	0.985
SOSMTMX	48.57	68.64	156.90	0.131	0.133	0.736
BASMNMX	87.05	66.89	.	0.050	0.009	0.941

Table 6.17. (continued)

Variable	Mean	RMS Error	RMS % Error	Theil Statistics Bias	Variance	Covar.
COUTTMX	15208.00	789.26	5.30	0.058	0.218	0.724
WHUTTMX	4540.00	223.65	4.79	0.041	0.028	0.931
DBUTTMX	1314.00	190.38	14.77	0.035	0.005	0.960
RIUTTMX	525.19	9.08	1.74	0.001	0.073	0.926
SGUTTMX	6357.00	460.18	8.13	0.002	0.109	0.889
BAUTTMX	609.10	44.54	7.11	0.002	0.000	0.998
SBUTTMX	1949.00	249.69	12.84	0.000	0.069	0.931
SMUTTMX	1706.00	139.75	8.16	0.014	0.001	0.985
SOUTTMX	364.95	52.51	15.43	0.013	0.050	0.937
COSTTMX	15208.00	789.26	5.30	0.058	0.218	0.724
WHSTTMX	4540.00	223.65	4.79	0.041	0.028	0.931
DBSTTMX	1314.00	190.43	14.77	0.035	0.005	0.960
RISTTMX	525.19	9.08	1.74	0.001	0.073	0.926
SGSTTMX	6357.00	460.18	8.13	0.002	0.109	0.889
SBSTTMX	1949.00	249.69	12.84	0.000	0.069	0.931
SOSTTMX	366.81	51.37	15.25	0.024	0.068	0.908
BASTTMX	609.10	44.54	7.11	0.002	0.000	0.998
BEPCRMXN	4092.00	728.05	12.03	0.000	0.175	0.825
CWCOTMX	13627.00	780.19	5.74	0.421	0.081	0.498
CWCOTMXL	9.52	0.06	0.58	0.412	0.079	0.509
CVSNBMX	8636.00	471.94	5.70	0.363	0.001	0.636
CECOTMX	32131.00	2421.00	7.72	0.546	0.004	0.450
CEKTNMX	7018.00	721.19	9.70	0.036	0.017	0.947
CEKTNMXL	8.84	0.10	1.08	0.031	0.016	0.952
BESPRMX	1415.00	118.07	7.89	0.039	0.028	0.934
CETXNMX	708.19	252.59	46.13	0.007	0.260	0.733
BETMNMX	21.52	49.52	.	0.084	0.391	0.525
CEUDLMX	960.52	127.93	14.88	0.199	0.038	0.763
CECITMX	32182.00	2401.00	7.64	0.514	0.015	0.472
BESSTMX	1446.00	144.46	9.11	0.000	0.174	0.826
SWCOTMX	918.43	40.11	4.43	0.048	0.358	0.595
SWCDFMX	2.38	45.00	.	0.005	0.365	0.630
SWCITMX	916.05	37.45	4.09	0.101	0.272	0.627
PGSNBMX	14612.00	874.83	5.69	0.067	0.112	0.821
HPKTNMX	12088.00	1164.00	10.37	0.000	0.160	0.840
POSPRMX	875.38	92.87	11.88	0.000	0.009	0.991
POSMTMX	18.81	14.37	200.50	0.247	0.398	0.355
POSTTMX	892.90	72.12	8.30	0.005	0.075	0.921
POSMNMX	17.52	56.64	.	0.007	0.515	0.478
POUTTMX	892.90	72.12	8.30	0.005	0.075	0.921

Table 6.17. (continued)

Variable	Mean	RMS Error	RMS % Error	Theil Statistics Bias	Variance	Covar.
PYSPRMX	643.29	63.67	10.38	0.002	0.021	0.977
PYSMTMX	47.95	94.30	771.43	0.336	0.001	0.664
BEUDCPKG	18.41	1.72	8.85	0.000	0.022	0.978
POUDCPKG	11.70	0.97	8.30	0.004	0.086	0.911
PYUDCPKG	8.62	1.29	14.30	0.311	0.073	0.616
BEUDCPKL	2.90	0.09	3.05	0.001	0.036	0.963
POUDCPKL	2.45	0.08	3.36	0.009	0.068	0.923
PYUDCPKL	2.11	0.16	7.82	0.325	0.015	0.660
BEUDCMX	1436.00	141.95	8.85	0.004	0.135	0.861
POUDCMX	892.90	72.12	8.30	0.005	0.075	0.921
PYUDCMX	690.52	109.30	14.30	0.279	0.151	0.570

CHAPTER 7. BASELINE AND ALTERNATIVE SCENARIOS

This chapter presents the policy assumptions for the baseline and the three policy scenarios. The scenarios for Mexico's agricultural economy analyze an exchange rate devaluation of 10 percent and three policy analyses: PROCAMPO, NAFTA, and pre-GATT policy.

The baseline for Mexico's agricultural sector model assumes the actual polices used from 1994 through mid-2000. Policies assumed for the baseline from 2000 through 2005 are based on the most likely scenario for decisions that will be made by the government of Mexico. These assumptions do not necessarily strictly adhere to policies of NAFTA, PROCAMPO, or GATT, but are based on how these policies and agreements have actually been implemented. For example, under NAFTA the government of Mexico could have imposed a tariff of 215 percent on corn imports in 1995 because corn imports exceeded the tariff-rate quota of 2.5 million metric tons. The government of Mexico has not imposed this tariff, but rather has allowed all imports exceeding the tariff-rate quota to enter at a tariff-free rate. Tariff-rate quotas also have not been applied to other commodities, such as dry beans, poultry, and barley.

The scenarios for the different sets of NAFTA and PROCAMPO policies begin in the years as stated in the agreements and adhere strictly to the agreements as specified, to the year 2005. The scenarios were conducted over a short historical period and a projected baseline, from 1994 through 2005. The projected U.S. prices used for the scenarios are from the Food and Agricultural Policy Research Institute's agricultural outlook for 2000 (1998).

Elimination of guaranteed and agreement prices under NAFTA and PROCAMPO opens Mexico's agricultural economy, and prices become aligned to international prices. Most of Mexico's imports are from the United States and are small enough not to have a significant effect on world prices. Thus, in this scenario, Mexico's crop prices are aligned to U.S. border prices for grains and livestock, including a transportation cost.

In the PROCAMPO policy scenario, guaranteed and agreement price supports for agricultural products are phased out over a transition period for all crops. This phase-out began in the 1993/94 marketing year, and full implementation of PROCAMPO was assumed to take place in 1995. Under PROCAMPO, producers are given fixed payments based on the number of hectares they farm. The fixed payments are decoupled from production decisions. Therefore, payments to producers do not need to be incorporated in the policy analysis, and only the transition to international prices is included. The PROCAMPO fixed payments to farmers will be gradually phased out over 15 years.

The second scenario analyzed is a "strict NAFTA" scenario. This analysis is conducted by aligning Mexico's domestic price to international prices and imposing tariffs as agreed upon under the NAFTA agreement. When imports exceed the tariff-rate quota for corn, dry beans, and barley, the out-of-quota tariff is applied.

The pre-GATT scenario assumes that NAFTA, GATT, and PROCAMPO do not exist, and tariffs are applied to maintain a price wedge between domestic and international prices, which is similar to policies that existed prior to 1994. Prior to GATT, NAFTA, and PROCAMPO, Mexico protected the major crops from imports through quotas. The domestic market to producers was then supported above international prices. Prices to consumers were similar to international prices because the government of Mexico subsidized prices, especially in the major commodities of corn and dry beans, which were the most protected.

Baseline Policy

The baseline policy is the policy implemented by the government of Mexico from 1994 through mid-1998 and is the policy that is expected to be continued. The tariffs applied in the baseline are provided in Table 7.1. In the baseline, no commodity is subject to trade barriers greater than those established under NAFTA, which was enacted on January 1, 1994. However, some commodities have more liberal trade policies than policies under NAFTA or GATT, including corn, dry beans, barley, and poultry. Policies for a large number of commodities have adhered to NAFTA policy and will do so in the foreseeable future, including pork, sorghum, wheat, rice, and soybeans.

Table 7.1. Baseline policy: tariff applied to border prices

	Percentage											
Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Corn	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dry beans	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wheat	15.0	13.5	12.0	10.5	9.0	7.5	6.0	4.5	3.0	1.5	0.0	0.0
Rice	10.0	9.0	8.0	7.0	6.0	5.0	4.0	3.0	2.0	1.0	0.0	0.0
Barley	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sorghum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Soybean	10.0	9.0	8.0	7.0	6.0	5.0	4.0	3.0	2.0	1.0	0.0	0.0
Soybean meal	15.0	13.5	12.0	10.5	9.0	7.5	6.0	4.5	3.0	1.5	0.0	0.0
Soybean oil	15.0	13.5	12.0	10.5	9.0	7.5.	6.0	4.5	3.0	1.5	0.0	0.0
Beef	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pork	20.0	18.0	16.0	14.0	12.0	10.0	8.0	6.0	4.0	2.0	0.0	0.0
Poultry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

The baseline policy for corn has no trade restriction. A tariff on imports above the tariff-rate quota has not been applied by the Mexican government, and therefore imports in the baseline above-tariff-rate quota levels are imported duty free. Mexico has imported corn from the United States in amounts above the tariff-rate quota in all years since the beginning of NAFTA. The government of Mexico increases the quota amount without imposing a tariff when domestic supply is insufficient. Corn is the major food staple, with per capita consumption of 128 kilograms per year in 1996 (Food and Agricultural Organization 1998). Mexican corn production often suffers from poor weather conditions. The government of Mexico will continue to provide sufficient corn at reasonable prices, which requires corn to be imported at world prices without imposing the tariff-rate quota.

Baseline policy for dry beans and barley applies no tariff. Although tariff-rate quotas exist under NAFTA and GATT, these have not been enforced. In 1996, Mexico imported dry beans above the tariff-rate quota because production was poor due to both a drought and a freeze affecting dry bean production, and no tariff was applied.

In the baseline, a number of commodities have policy assumptions in accordance with NAFTA. Sorghum has no trade restrictions, which is consistent with NAFTA. Tariffs on sorghum were eliminated in 1994. Baseline trade policy for wheat and rice is incorporated in accordance with NAFTA. Wheat is imported with a tariff, beginning at 15 percent in 1994 that is phased out over 10 years. Rough rice is imported with a 20 percent tariff starting in 1994 that is phased out over 10 years. Imported rough rice has a 10 percent tariff starting in 1994 that is phased out over 10 years. Most of Mexico's rice imports are rough rice from the United States, which provides an indirect subsidy to Mexico's domestic millers.

Baseline policy for soybeans, soybean meal, and soybean oil is incorporated according to NAFTA because this is the current policy being imposed by the government of Mexico. Soybeans have a 10 percent tariff beginning in 1994 that is phased out over a 10-year period. Soybean meal and soybean oil each have a 15 percent tariff beginning in 1994 that is phased out over 10 years.

Among the livestock sectors, only pork and slaughter hogs have a tariff of 20 percent beginning in 1994 that phased out over 10 years. No trade barriers exist for beef and cattle. Poultry has a tariff-rate quota that has not been applied and most likely will not be applied in the future.

The Mexican government also applied support prices to assist in the adjustment to a more open economy. These support prices were for corn, wheat, sorghum, dry beans, and soybeans and applied only in 1994, when the support price was higher than the international price. After the depreciation of the peso, the international price was higher than the domestic support price.

Retail prices are linked to border prices through estimated equations and industry transportation costs. Corn and dry bean retail prices are exogenous because of government intervention. The government of Mexico subsidizes corn and dry beans to consumers, which cuts the link between farm and retail prices.

Devaluation and Crop Production

The government of Mexico has often supported its currency value above the free market international value, which eventually leads to devaluation as these policies become difficult to maintain. The consequences to Mexico's agricultural economy from a currency devaluation can be analyzed within this modeling framework by a 10 percent devaluation in the Mexican peso each year from 1993 to 2005. In Table 7.2, the effects from a 10 percent currency devaluation of the Mexican peso are presented. The 10 percent devaluation increases the border price by exactly 10 percent for all years. Under the baseline, domestic prices are aligned with international prices and Mexico is assumed to be a small country with no effect on the international price. Therefore, a devaluation in each year increases the domestic and international prices, to which producers, consumers, and importers will respond. Because it is assumed devaluation began in 1993 there is no lagged effect present in production decision. As Mexico increases its market share of U.S. agricultural exports, the validity of a small-country assumption may come under question.

As a result of higher domestic prices to farmers, area harvested increased for all commodities in each year relative to the baseline. The average increase in area harvested was 1.15 percent per year for all the commodities, excluding soybeans. Soybeans are the most responsive to prices, increasing by 8 percent to 25 percent in area harvested. An increase in production is consistent with economic expectations because these commodities are now more profitable compared to the baseline scenario. Corn production increases by 0.4 percent per year on average, which is the smallest increase among all the commodities studied. Corn is staple food in Mexico and large amounts are consumed on the farm instead of being marketed. Corn production is less sensitive to market prices and substitutes. Dry bean production increases by 1.2 percent per year throughout the simulation relative to the baseline. Wheat and rice production both average 2.3 percent to 2.5 percent increases per year relative to the baseline. Soybean production increases the most due to strong own-price elasticity. Increases in soybean production range from 8 percent to 29 percent.

The higher domestic prices affect consumers' purchasing decisions and reduce consumption of most commodities. Only corn for food consumption increases, which is caused by the positive cross-price elasticities of wheat and dry beans and the assumption that corn prices are still subsidized by

Table 7.2. Ten percent currency devaluation scenario

	Percent Change from Baseline											
Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Area												
Corn	0.46	0.48	0.45	0.50	0.46	0.43	0.42	0.42	0.42	0.42	0.42	0.42
Dry beans	0.82	1.08	1.12	1.23	1.10	1.07	1.08	1.06	1.06	1.06	1.06	1.06
Wheat	1.08	1.16	1.16	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17
Rice	1.87	1.96	1.94	1.71	1.65	1.57	1.57	1.56	1.56	1.55	1.54	1.54
Barley	0.89	1.19	1.23	1.18	1.15	1.14	1.13	1.13	1.13	1.13	1.13	1.13
Sorghum	0.89	0.89	0.85	0.85	0.83	0.80	0.83	0.83	0.84	0.84	0.84	0.84
Soybeans	8.10	24.63	29.49	20.92	17.39	14.62	15.11	15.31	15.65	15.98	16.70	17.12
Production												
Corn	0.46	0.48	0.45	0.50	0.46	0.43	0.42	0.42	0.42	0.42	0.42	0.42
Dry beans	0.98	1.25	1.29	1.38	1.22	1.18	1.19	1.17	1.17	1.16	1.16	1.16
Wheat	2.30	2.47	2.42	2.37	2.35	2.33	2.36	2.36	2.36	2.36	2.35	2.36
Rice	2.43	3.01	3.07	2.67	2.48	2.23	2.18	2.16	2.14	2.12	2.08	2.07
Barley	0.89	1.19	1.23	1.18	1.15	1.14	1.13	1.13	1.13	1.13	1.13	1.13
Sorghum	1.33	1.76	1.38	1.28	1.17	1.08	1.15	1.15	1.15	1.15	1.14	1.13
Soybeans	8.10	24.63	29.49	20.92	17.39	14.62	15.11	15.31	15.65	15.98	16.70	17.12
Consumption												
Corn	-2.05	-2.14	-2.21	-2.24	-2.15	-2.60	-2.70	-2.70	-2.68	-2.64	-2.61	-2.59
Dry beans	-0.41	-0.43	-0.43	-0.53	-0.53	-0.53	-0.50	-0.50	-0.50	-0.51	-0.51	-0.52
Wheat	-0.81	-1.04	-1.09	-1.09	-1.11	-1.11	-1.11	-1.12	-1.11	-1.10	-1.10	-1.10
Rice	-0.04	-0.41	-0.34	-0.34	-0.34	-0.34	-0.34	-0.34	-0.34	-0.34	-0.34	-0.34
Barley	-1.08	-1.05	-1.08	-1.14	-1.14	-1.15	-1.16	-1.16	-1.17	-1.17	-1.18	-1.19
Sorghum	-2.71	-2.69	-2.96	-2.75	-2.48	-2.56	-2.71	-2.77	-2.78	-2.77	-2.78	-2.82
Soybeans	-3.33	-2.25	-2.42	-2.63	-2.51	-2.33	-2.24	-2.19	-2.14	-2.09	-2.07	-2.02
Soybean meal	-2.66	-2.62	-2.88	-2.68	-2.40	-2.49	-2.63	-2.70	-2.70	-2.70	-2.71	-2.75
Soybean oil	-2.11	-1.99	-1.97	-1.93	-2.05	-2.21	-2.27	-2.27	-2.27	-2.27	-2.27	-2.27
Corn food	0.51	0.52	0.53	0.53	0.52	0.54	0.56	0.56	0.56	0.57	0.57	0.57
Wheat food	-0.30	-0.54	-0.58	-0.61	-0.62	-0.63	-0.63	-0.63	-0.63	-0.63	-0.63	-0.63
Corn feed	-9.15	-7.31	-7.93	-7.70	-7.43	-8.45	-8.84	-8.99	-9.05	-9.04	-8.96	-8.95
Wheat feed	-9.06	-8.70	-9.02	-10.32	-9.98	-9.93	-9.70	-9.39	-9.37	-9.17	-9.36	-9.05
Net Imports												
Corn	-16.28	-9.51	-18.93	-13.52	-9.89	-15.07	-28.68	-29.55	-28.75	-27.44	-25.49	-24.42
Dry beans	-51.53	-30.61	-23.43	-15.26	-27.83	-36.96	-21.45	-29.45	-34.55	-21.96	-21.26	-15.56
Wheat	-8.11	-8.87	-6.58	-7.63	-6.44	-5.99	-5.96	-5.91	-5.83	-5.74	-5.54	-5.44
Rice	-2.21	-3.42	-3.29	-3.43	-3.25	-2.96	-2.84	-2.81	-2.81	-2.78	-2.75	-2.72
Barley	-10.43	-7.00	-12.35	-10.36	-9.86	-9.12	-8.71	-8.31	-8.12	-7.84	-7.40	-7.16
Sorghum	-10.43	-11.89	-12.57	-10.64	-8.77	-9.14	-10.19	-10.85	-11.03	-11.14	-11.21	-11.37
Soybeans	-6.00	-4.73	-4.57	-3.99	-3.35	-3.03	-2.92	-2.89	-2.85	-2.81	-2.75	-2.70
Soybean meal	-1.71	-3.52	-4.16	-2.78	-1.57	-4.44	-8.66	-10.27	-11.15	-12.28	-14.40	-17.00
Soybean oil	3.22	-0.15	-0.10	1.29	1.53	-0.71	-2.70	-3.43	-3.77	-3.99	-3.93	-3.94

Table 7.2. (continued)

	Percent Change from Baseline											
Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Border Price												
Corn	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Dry beans	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Wheat	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Rice	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Barley	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Sorghum	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Soybeans	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Retail Price												
Corn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wheat	6.96	6.96	6.96	6.96	6.96	6.96	6.96	6.96	6.96	6.96	6.96	6.96
Dry beans	8.86	8.86	8.86	8.86	8.86	8.86	8.86	8.86	8.86	8.86	8.86	8.86
Rice	4.34	9.99	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Production												
Beef	-2.28	-2.63	-2.12	-1.04	0.46	1.65	2.36	2.78	3.11	3.45	3.84	4.25
Pork	-2.35	-3.16	-3.48	-2.76	-1.76	-1.46	-1.66	-1.79	-1.74	-1.62	-1.43	-1.33
Poultry	-2.85	-2.33	-2.53	-2.71	-2.85	-2.98	-3.03	-3.00	-2.97	-2.94	-2.90	-2.86
Consumption												
Beef	-0.95	-0.97	-1.07	-1.04	-0.97	-0.98	-0.98	-0.98	-1.01	-1.00	-1.01	-1.01
Pork	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poultry	-1.15	-1.07	-1.11	-1.24	-1.08	-1.05	-1.15	-1.20	-1.25	-1.27	-1.27	-1.27
Net Imports												
Beef	66.96	37.69	-46.11	9.86	-48.80	-115.01	-36.06	-23.05	-23.68	-24.15	-28.44	-31.03
Pork	31.05	57.06	48.05	39.17	22.88	19.47	12.18	10.63	9.41	8.42	7.11	6.32
Poultry	20.43	18.50	16.96	16.33	22.15	24.49	28.50	25.17	22.20	21.42	23.93	25.70
Exports												
Cattle	0.98	0.89	0.86	0.85	0.82	0.99	1.68	2.08	2.31	2.46	2.61	2.77
Border Price												
Beef	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Pork	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Poultry	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

the government of Mexico. Therefore the full price transmission of higher international prices does not affect corn prices.

Because of the devaluation, the border price increases by 10 percent for all livestock. This change has both positive and negative effects for Mexico's livestock and poultry industries. Mexico is a major exporter of light-weight cattle, or feeder cattle, to United States. The currency devaluation has a positive economic effect on the cattle industry. As indicated in Table 7.2, cattle exports increased by almost 1 percent in the first year (1994) and then increase by 2.8 percent by 2005 compared to the baseline. The increase in cattle exports initially leads to a decline in beef production as cattle herds are rebuilt and fewer cows are slaughtered. Larger numbers of light-weight cattle are exported instead of being grass-fed and slaughtered for domestic consumption. In the longer term, as cattle herds increase, more beef is available for domestic consumption, as indicated by the turnaround in 1998. Initially, beef production decreases by about 2.5 percent and then increases by 0.5 percent in 1998. By 2005, beef production increases by 4.25 percent compared to the baseline. The cattle industry is not affected by higher feed prices as much as the pork and poultry industries because most beef production continues to be grass-fed cattle and cow-calf operations that produce feeder cattle for the export industry use grass-fed production.

The pork and poultry industries are highly dependent on the cost of feed grains. Therefore, a 10 percent currency devaluation increases the cost of production for pork and poultry. The increased production cost resulting from increased feed costs eliminates less profitable producers and production decreases. Pork production decreases throughout the simulation, from 3.5 percent in early 1990s to 1.3 percent by 2005 relative to the baseline. Poultry production decreases each year throughout the simulation, averaging 2.8 percent. The devaluation increases feed costs, which results in less feed demand for sorghum, soybean meal, corn, and wheat. The feed demands that decrease the most in percentage terms are corn and wheat, which are very sensitive to own price and the prices of other feed grains. Also, corn and wheat as feed grains are used in relatively small amounts compared to sorghum and soybean meal use. The decreases in feed demand for corn and wheat average 8 percent to 9 percent per year, respectively, throughout the simulation. Sorghum and soybean meal feed demand decrease by 2 percent to 3 percent, respectively, throughout the simulation relative to the baseline.

Beef and poultry consumption decrease because of higher prices resulting from the currency devaluation. Beef consumption decreases by 1.00 percent per year, and the average decrease in poultry consumption is 1.15 percent throughout the simulation. Pork consumption is not affected because the own-price elasticity and poultry cross-price elasticity exactly offset each other due to a 10 percent increase in the border price for both commodities.

Pork and poultry imports increase because production decreases below the capacity to satisfy domestic demand. Initially, pork imports increase by 30 percent to 40 percent. By 2005, however, pork imports increase by only 6.5 percent relative to the baseline. Beef imports increase in the first couple of years as production decreases; however, as production increases, beginning in 1998, imports decrease by 20 percent to 40 percent.

PROCAMPO Scenario

Under the PROCAMPO scenario, domestic crop prices are aligned with international prices. The government of Mexico provides policy information about PROCAMPO to farmers. Farmers base production decisions on expected prices incorporating the effects of PROCAMPO. Therefore farmers are forward-looking in prices with respect to policy implementation and there is no lagged effect from elimination of tariffs in farmers' production decisions. Table 7.3 presents the tariffs applied to the border price for this scenario, which is an elimination of tariffs beginning in 1995 for the crops. Producers are provided with income support payments, which are decoupled from agricultural production decisions. The income support is designed to assist farmers in adjusting to international prices. Because the income support is decoupled, it is not incorporated into the policy scenarios. The crops under PROCAMPO include corn, wheat, sorghum, rice, soybeans, dry beans, safflower, barley, and cotton.

Table 7.3. PROCAMPO policy scenario: tariff applied to border prices

	percent											
Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Corn	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dry beans	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wheat	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Barley	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sorghum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Soybean	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.0
Soybean meal	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Soybean oil	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Beef	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pork	20.0	18.0	16.0	14.0	12.0	10.0	8.0	6.0	4.0	2.0	0.0	0.0
Poultry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

The scenario was conducted by eliminating tariffs for commodities under PROCAMPO, including a rice tariff of 10 percent, a wheat tariff of 15 percent, a soybean tariff of 10 percent, and soybean meal and soybean oil tariffs of 15 percent. A number of commodities do not have trade restrictions in the baseline: sorghum, corn, dry beans, poultry, and beef. Tariff-rate quotas have not been imposed by Mexico for these commodities. Baseline restrictions on pork imports are maintained because pork is not a commodity under PROCAMPO.

The PROCAMPO scenario was conducted by eliminating tariffs for some commodities, including a rice tariff of 10 percent, a wheat tariff of 15 percent, a soybean tariff of 10 percent, and soybean meal and soybean oil tariffs of 15 percent. The tariffs are eliminated beginning in 1995, which is consistent with PROCAMPO policy. Under PROCAMPO, domestic prices are aligned with international prices. U.S. f.o.b. prices are used as the border price, including a cost of transportation.

The government of Mexico informed farmers of PROCAMPO policy prior to actual implementation. Therefore, farmers had prior information of PROCAMPO policy and elimination of tariffs beginning in 1995 was anticipated by farmers and production decision is adjusted accordingly beginning in 1995.

The initial effect of eliminating the tariffs for wheat, rice, soybeans, soybean meal, and soybean oil is a lowering of domestic prices to producers. In Table 7.4, harvested area decreases for wheat, rice, and soybeans relative to the baseline. These crops become less profitable with lower domestic prices, and producers make decisions to reduce the amount of area planted to these crops. The initial decrease in area harvested is highest for soybeans, at 24.23 percent, but this level gradually reduces to a decrease of 1.93 percent by year 2003. The gradual decrease in area harvested is a result of the current NAFTA policy that gradually decreases tariffs over a 10-year period and is eliminated in the PROCAMPO scenario. Wheat and rice harvested area decrease by 2.42 percent and 1.21 percent, respectively, in 1995 relative to the baseline. This decline slows to a decrease in area harvested of 0.29 percent and 0.11 percent, respectively, by 2003. In 2004 and 2005, there is no effect on area harvested because the baseline is zero in these years under NAFTA.

Corn, dry bean, and sorghum area harvested and production are not affected because these crops have traditionally been grown in different regions than wheat, rice, and soybeans. Wheat, rice, and soybeans are traditionally grown in the Pacific north. Corn, dry beans, and sorghum are grown in the Pacific central, north central, and central regions, and a lot of sorghum is grown in the Gulf region. Soybean production shows the largest decrease among the crops, at 24 percent in 1995 and then declining to a 2 percent decrease by 2003 relative to the baseline. Production decreases in wheat and

Table 7.4. PROCAMPO policy scenario

	Percent Change from Baseline											
Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Area												
Corn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry beans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wheat	0.00	-2.42	-2.17	-1.92	-1.66	-1.40	-1.13	-0.85	-0.57	-0.29	0.00	0.00
Rice	0.00	-1.21	-1.07	-0.82	-0.68	-0.54	-0.43	-0.33	-0.22	-0.11	0.00	0.00
Barley	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sorghum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Soybeans	0.00	-24.23	-26.09	-16.39	-11.82	-8.39	-7.02	-5.40	-3.73	-1.93	0.00	0.00
Production												
Corn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry beans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wheat	0.00	-4.07	-3.60	-3.13	-2.69	-2.25	-1.83	-1.39	-0.93	-0.47	0.00	0.00
Rice	0.00	-1.93	-1.87	-1.47	-1.17	-0.88	-0.69	-0.52	-0.35	-0.19	-0.02	-0.01
Barley	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sorghum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Soybeans	0.00	-24.23	-26.09	-16.39	-11.82	-8.39	-7.02	-5.40	-3.73	-1.93	0.00	0.00
Consumption												
Corn	0.00	-0.13	-0.09	-0.04	0.00	0.07	0.08	0.07	0.05	0.04	0.03	0.02
Dry beans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wheat	0.00	1.37	1.41	1.33	1.20	1.01	0.82	0.62	0.43	0.24	0.05	0.01
Rice	0.00	0.08	0.24	0.19	0.17	0.15	0.12	0.10	0.07	0.05	0.03	-0.00
Barley	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sorghum	0.00	0.93	0.83	0.78	0.74	0.71	0.60	0.46	0.32	0.18	0.02	0.03
Soybeans	0.00	1.77	1.82	1.79	1.50	1.16	0.90	0.66	0.43	0.22	0.01	0.00
Soybean meal	0.00	1.81	1.80	1.68	1.53	1.38	1.15	0.88	0.61	0.34	0.07	0.05
Soybean oil	0.00	2.71	2.40	2.07	1.89	1.71	1.41	1.07	0.71	0.36	0.00	0.00
Corn food	0.00	-0.46	-0.41	-0.37	-0.31	-0.27	-0.23	-0.17	-0.12	-0.06	0.00	0.00
Wheat food	0.00	0.49	0.65	0.64	0.58	0.50	0.41	0.32	0.23	0.14	0.05	0.01
Corn feed	0.00	0.51	0.57	0.62	0.61	0.72	0.65	0.53	0.39	0.25	0.10	0.06
Wheat feed	0.00	14.55	13.33	14.40	12.36	10.31	7.98	5.76	3.87	1.93	0.07	0.05
Net Imports												
Corn	0.00	-0.49	-0.68	-0.20	0.00	0.38	0.73	0.64	0.51	0.40	0.30	0.17
Dry beans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wheat	0.00	12.62	9.32	9.89	7.28	5.73	4.61	3.50	2.39	1.30	0.22	0.03
Rice	0.00	1.80	2.13	1.87	1.55	1.19	0.92	0.70	0.49	0.27	0.06	-0.01
Barley	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sorghum	0.00	2.87	2.67	2.30	2.00	1.98	1.77	1.42	1.00	0.55	0.06	0.10
Soybeans	0.00	4.28	3.69	2.83	2.05	1.55	1.20	0.90	0.59	0.29	0.00	0.00
Soybean meal	0.00	2.19	1.74	1.25	1.66	3.80	4.74	4.00	3.15	2.17	0.95	0.96
Soybean oil	0.00	10.01	4.80	3.31	4.89	8.72	9.70	6.82	4.00	1.76	-0.06	-0.00

Table 7.4. (continued)

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	Percent Change from Baseline											
Border Price												
Corn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry beans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wheat	0.00	-11.89	-10.71	-9.50	-8.26	-6.98	-5.66	-4.31	-2.91	-1.48	0.00	0.00
Rice	0.00	-8.26	-7.41	-6.54	-5.66	-4.76	-3.85	-2.91	-1.96	-0.99	0.00	0.00
Barley	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sorghum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Soybeans	0.00	-8.26	-7.41	-6.54	-5.66	-4.76	-3.85	-2.91	-1.96	-0.99	0.00	0.00
Retail Price												
Corn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry beans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wheat	0.00	-10.67	-9.60	-8.51	-7.39	-6.24	-5.06	-3.85	-2.60	-1.32	0.00	0.00
Rice	0.00	-5.88	-7.78	-6.98	-6.10	-5.23	-4.27	-3.35	-2.41	-1.45	-0.48	0.00
Production												
Beef	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pork	0.00	0.64	0.74	0.81	0.77	0.67	0.59	0.49	0.39	0.29	0.19	0.13
Poultry	0.00	1.95	1.89	1.77	1.61	1.41	1.15	0.85	0.57	0.28	0.00	0.00
Consumption												
Beef	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pork	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poultry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net Imports												
Beef	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pork	0.00	-11.56	-10.24	-11.49	-9.99	-8.99	-4.34	-2.92	-2.10	-1.49	-0.94	-0.63
Poultry	0.00	-30.12	-24.12	-21.23	-21.05	-18.63	-18.13	-12.54	-7.73	-3.82	0.00	0.00
Exports												
Cattle	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Border Price												
Beef	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pork	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poultry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

rice are more moderate, at 4 percent and 2 percent, respectively, in 1995 and 0.47 percent and 0.19, respectively, by 2003.

Elimination of tariffs under PROCAMPO results in lower prices and affects consumers' food purchasing decisions for many commodities. Initially, wheat, rice, soybean meal, and soybean oil each show an increase in consumption relative to the baseline. Soybean oil consumption increases the most, at 2.71 percent in 1994, and then gradually slows to an increase of 0.34 percent by 2003. Wheat consumption increases by 1.37 percent in 1994, which has a negative effect on corn food consumption because corn and wheat are substitutes. By 2003 and 2004, wheat consumption increases by only 0.24 percent and 0.05 percent, respectively, relative to the baseline. Wheat feed demand increases the most among the crops, at 14.55 percent in 1994 and gradually slows to a 1.93 percent increase by 2003. The increase is large because wheat utilized as feed is relatively small and small quantity increases in demand result in larger percentage changes. Corn food consumption decreases by 0.46 percent in 1994 and gradually slows to a decrease of 0.03 percent by 2003.

Most of the commodities exhibit increased imports; the exceptions are dry beans and barley, which are not affected. Corn imports decrease the first couple of years because the decrease in food demand was greater than the increase in feed demand. Wheat imports increase by 12.62 percent in 1994 because lower production and lower domestic prices increase both wheat food and feed demand. By 2003, wheat imports slow to a 1.3 percent increase. Soybean oil imports increase by 10 percent in 1994.

The cattle industry is not affected by PROCAMPO policies. Feed grain prices have little effect on cattle in Mexico because most cattle are grass fed. Due to the lower prices for soybean meal and wheat, both pork and poultry production increase, which causes increased feed grain demand for crops such as sorghum. Sorghum imports increase by 2.87 percent in 1994 and are 0.33 percent greater than the baseline by 2003. Due to increased pork and poultry production, pork and poultry imports decrease. In 1994, poultry imports decrease by 30 percent, which gradually slows to 4 percent decrease by 2003. Pork imports are not as strong, starting with an 11.56 percent decrease in 1994 and then decreasing by 1.49 percent by 2003.

NAFTA Policy Scenario

Under the NAFTA policy scenario, policies are implemented that are consistent with the NAFTA agreement. The analysis begins in 1994, which is consistent with actual NAFTA policy. Four commodities have tariffs that are different from the baseline. These commodities are corn, dry beans, barley, and poultry, which are the only commodities with tariff-rate quotas. When imports for these commodities are greater than the agreed quota, a tariff up to a specific maximum level can be applied to the commodity. Since inception of NAFTA, the tariff-rate quotas have not been applied when imports have exceeded quotas. In Table 7.5, the quota amounts and tariff rates are listed for corn, dry beans, barley, and poultry.

The tariffs applied in the NAFTA policy scenario are presented in Table 7.6. The tariffs applied to the tariff-rate quota commodities of corn, dry beans, barley, and poultry are endogenous. The tariffs are not exogenous but are solved within the model to minimize imports to be equal to or slightly below the quota amounts, provided that the tariffs are not greater than the maximum allowable levels. Imports below the quota amount have no tariff applied. The tariffs vary from year to year, depending on the quantity of imports in the baseline. In 1994, for example, imports of corn were higher than the quota amount; therefore, a tariff of 7.1 percent was applied as indicated in Table 7.6. In Table 7.7, the tariff reduces imports by 483,000 metric tons, to the quota level of 2.50 million metric tons. It is assumed that the government of Mexico is forward-looking and able to inform

Table 7.5. NAFTA policy for quotas and tariffs under tariff-rate quotas

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Quotas (1,000 metric tons)												
Corn	2,500	2,575	2,652	2,731	2,813	2,898	2,985	3,074	3,166	3,261	3,359	3,564
Dry Beans	50.0	51.5	53.1	54.6	56.3	57.9	59.7	61.5	63.3	65.2	67.2	69.2
Barley	120.0	126.0	132.3	138.9	145.9	153.2	160.8	168.8	177.3	186.2	195.5	205.2
Poultry	95.0	97.9	100.8	103.8	106.9	110.1	113.4	116.8	120.3	123.9	127.7	131.5
Maximum tariffs permitted (percent)												
Corn	215	205	194	184	174	163	145	127	109	91	73	54
Beans	139	132	126	119	112	106	94	82	70	59	47	35
Barley	152	136	121	106	91	76	61	45	30	15	0	0
Poultry	197	177	157	137	118	98	79	59	39	19	0	0

Table 7.6. NAFTA policy scenario: tariffs applied to border prices

	Percentage											
Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Tariffs applied under tariff-rate quota												
Corn	7.1	57.0	1.9	21.9	46.4	16.5	0.0	0.0	0.0	0.0	0.0	0.0
Beans	0.0	11.5	23.5	52.0	4.5	0.0	28.0	3.2	1.4	23.5	20.3	35.2
Barley	0.0	62.0	0.0	0.0	0.0	3.0	4.0	6.0	4.7	5.0	0.0	0.0
Poultry	2.0	0.0	2.0	2.7	1.9	2.1	0.0	0.5	1.3	1.3	0.0	0.0
Tariffs consistent with baseline												
Wheat	15.0	13.5	12.0	10.5	9.0	7.5	6.0	4.5	3.0	1.5	0.0	0.0
Rice	10.0	9.0	8.0	7.0	6.0	5.0	4.0	3.0	2.0	1.0	0.0	0.0
Sorghum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Soybean	10.0	9.0	8.0	7.0	6.0	5.0	4.0	3.0	2.0	1.0	0.0	0.0
Soybean meal	15.0	13.5	12.0	10.5	9.0	7.5	6.0	4.5	3.0	1.5	0.0	0.0
Soybean oil	15.0	13.5	12.0	10.5	9.0	7.5	6.0	4.5	3.0	1.5	0.0	0.0
Beef	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pork	20.0	18.0	16.0	14.0	12.0	10.0	8.0	6.0	4.0	2.0	0.0	0.0

Table 7.7. NAFTA policy scenario: imports under base and NAFTA scenario

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	1,000 metric tons											
Corn												
Base	2,983	6,001	3,042	4,328	5,880	4,502	2,448	2,399	2,468	2,585	2,791	2,923
Scenario	2,500	2,574	2,652	2,731	2,813	2,898	2,210	2,361	2,462	2,569	2,768	2,895
Difference	-483	-3,427	-390	-1597	-3067	-1604	-238	-38	-6	-16	-23	-28
Beans												
Base	36	73	100	140	77	58	106	79	69	108	113	155
Scenario	36	52	53	55	56	54	59	61	63	64	67	83
Difference	0	-21	-47	-85	-21	-4	-47	-18	-6	-44	-46	-72
Barley												
Base	107	182	109	133	142	156	166	177	184	194	209	219
Scenario	107	126	100	131	142	152	160	168	176	186	207	219
Difference	0	-56	-9	-2	0	-4	-6	-9	-8	-8	-2	-0
Poultry												
Base	93	115	125	121	127	110	121	133	137	126	120	107
Scenario	93	101	103	107	110	110	116	120	124	126	120	107
Difference	0	-14	-22	-14	-17	0	-5	-13	-13	0	0	0

producers of tariff policy prior to implementation. Therefore, producers have prior information of tariff policy and production decisions are adjusted accordingly in the years tariffs are applied. This also provides easier comparison of the PROCAMPO and pre-GATT policy results.

As shown in Table 7.8, the tariffs applied to wheat, rice, soybeans, soybean meal, soybean oil, and pork under NAFTA policies are the tariffs applied in the baseline. Sorghum and beef do not have tariffs under the baseline or under NAFTA policy. The initial effect of applying NAFTA policy is a result of applying tariffs to imports of corn, dry beans, barley, and poultry in amounts above the quota levels. In 1994, corn and poultry imports are greater than the quota level. Tariffs of 7.1 percent and 2.0 percent for corn and poultry, respectively, are solved for, which reduces imports to quota levels. The initial effect is an increase in domestic price to producers and consumers. As shown in Table 7.8, corn harvested area increases by 1.25 percent in 1994. Sorghum is a substitute crop, and sorghum harvested area decreases due to the higher corn prices. Farmers switch to corn because it is more profitable. The border price of corn increases by 7.12 percent in 1994.

Corn consumption decreases by 1.44 percent in 1994 because feed costs are now higher for pork and poultry producers. Feed corn demand decreases by 5.43 percent in 1994. Demand for the substitute feeds of wheat, soybean meal, and sorghum increases by 1.39 percent, 0.45 percent, and 0.59 percent, respectively. Food corn consumption is not affected because corn is subsidized and

Table 7.8. NAFTA policy scenario

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	Percent Change from Baseline											
Area												
Corn	1.25	9.14	0.81	5.03	7.20	2.61	0.51	0.06	0.03	0.43	0.38	0.62
Dry beans	0.00	1.05	2.23	4.96	1.29	0.23	2.36	0.70	0.25	1.98	2.05	3.16
Wheat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rice	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barley	0.00	4.80	1.32	0.35	0.09	0.28	0.42	0.62	0.56	0.57	0.15	0.04
Sorghum	-2.29	-14.11	-0.62	-6.21	-11.20	-4.54	0.00	0.00	0.00	0.00	0.00	0.00
Soybeans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Production												
Corn	1.25	9.14	0.81	5.03	7.20	2.61	0.51	0.06	0.03	0.43	0.38	0.62
Dry beans	0.00	1.25	2.65	5.75	1.34	0.23	2.66	0.74	0.26	2.23	2.25	3.51
Wheat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rice	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barley	0.00	4.80	1.32	0.35	0.09	0.28	0.42	0.62	0.56	0.57	0.15	0.04
Sorghum	-2.29	-14.11	-0.62	-6.21	-11.20	-4.54	0.00	0.00	0.00	0.00	0.00	0.00
Soybeans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Consumption												
Corn	-1.44	-8.83	-0.09	-3.60	-7.90	-4.54	-0.38	-0.05	0.04	0.32	0.25	0.40
Dry beans	0.00	-0.49	-0.94	-2.30	-0.24	0.00	-1.28	-0.16	-0.07	-1.13	-0.99	-1.63
Wheat	0.08	0.59	0.26	0.70	0.58	0.21	0.26	0.09	0.04	0.23	0.24	0.36
Rice	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barley	0.00	-4.99	-0.23	-0.01	-0.00	-0.34	-0.47	-0.70	-0.57	-0.60	-0.03	-0.00
Sorghum	0.59	3.07	1.39	1.88	3.09	2.19	0.76	0.33	0.22	0.15	0.01	0.01
Soybeans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Soybean meal	0.45	2.00	0.21	1.05	1.77	0.81	0.00	0.04	0.11	0.11	0.00	0.00
Soybean oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corn food	0.00	0.20	0.39	0.79	0.08	0.00	0.48	0.06	0.03	0.42	0.37	0.60
Wheat food	0.00	0.11	0.24	0.50	0.16	0.03	0.28	0.09	0.03	0.24	0.25	0.38
Corn feed	-5.43	-26.36	-1.09	-12.24	-23.71	-12.99	-2.01	-0.25	0.07	0.12	0.02	0.00
Wheat feed	1.39	7.81	0.47	4.51	8.34	3.40	0.00	0.04	0.11	0.11	0.00	0.00
Net Imports												
Corn	-16.19	-57.10	-12.83	-36.89	-52.15	-35.63	-9.70	-1.44	0.13	-0.23	-0.77	-0.96
Dry beans	0.00	-29.43	-46.79	-61.14	-27.18	-8.12	-44.12	-22.10	-8.52	-40.38	-41.23	-46.41
Wheat	0.28	1.92	0.66	2.02	1.48	0.50	0.63	0.22	0.09	0.54	0.55	0.82
Rice	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barley	0.00	-30.85	-7.71	-1.46	-0.36	-2.51	-3.40	-4.81	-4.00	-3.99	-0.51	-0.11
Sorghum	5.80	36.41	9.00	16.47	26.77	15.61	3.19	0.99	0.67	0.47	0.05	0.02
Soybeans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Soybean meal	1.49	7.07	0.46	4.90	13.57	9.75	-0.58	0.70	1.82	1.88	-0.10	0.00

Table 7.8. (continued)

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	Percent Change from Baseline											
Border Price												
Corn	7.12	56.99	1.94	21.93	46.36	16.50	0.00	0.00	0.00	0.00	0.00	0.00
Dry beans	0.00	11.50	23.50	52.00	4.50	0.00	28.00	3.17	1.35	23.50	20.30	35.20
Wheat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rice	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barley	0.00	62.00	0.00	0.00	0.00	3.00	4.00	6.00	4.70	5.00	0.00	0.00
Sorghum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Soybeans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Retail Price												
Corn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wheat	0.00	7.98	16.06	34.37	3.15	0.00	19.03	2.23	0.95	16.06	13.93	23.71
Dry beans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rice	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Production												
Beef	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pork	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poultry	0.23	0.00	0.21	0.29	0.22	0.25	0.00	0.06	0.16	0.15	0.00	0.00
Consumption												
Beef	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pork	0.80	0.14	0.82	1.16	1.10	1.26	0.25	0.28	0.64	0.72	0.15	0.03
Poultry	-0.72	0.00	-0.71	-1.04	-0.64	-0.69	0.00	-0.19	-0.51	-0.52	0.00	0.00
Net Imports												
Beef	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pork	11.34	2.63	12.13	17.63	15.48	18.00	2.11	1.91	4.08	4.48	0.89	0.18
Poultry	-12.82	0.00	-12.47	-17.05	-11.91	-13.22	0.00	-3.87	-9.64	-9.69	0.00	0.00
Exports												
Cattle	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Border Price												
Beef	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pork	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poultry	2.00	0.00	2.04	2.70	1.90	2.10	0.00	0.50	1.30	1.30	0.00	0.00

large amounts of corn are consumed on farms. Corn imports decreased by 16.19 percent in 1994, to the level of the tariff-rate quota. Sorghum imports increase by 5.8 percent because of decreased production.

The poultry border price increases by 2 percent because of the tariff. Due to higher domestic prices, poultry producers increase production by 0.23 percent. Higher domestic prices also affect consumers' purchasing decisions. Poultry consumption decreases by 0.72 percent in 1994. Increasing production and decreasing consumption of poultry result in a 12.82 percent decrease in poultry imports relative to the baseline.

Pre-GATT Policy Scenario

The pre-GATT scenario was conducted by applying tariffs to commodities that were most protected in Mexico prior to 1994. The domestic farm prices of these commodities were much higher than international prices. Table 7.9 lists average price differences in percentage terms between Mexico's domestic commodity prices and the international price for different time periods. Two of the most highly protected commodities are corn and dry beans. The government of Mexico has maintained price supports for most major commodities and restricted imports through quotas. Guaranteed prices were removed for most commodities by 1989, but the government of Mexico maintained price supports for corn and dry beans until 1995, which was the beginning of GATT implementation. Under GATT, Mexico is required to remove quotas and replace quotas with tariffs or tariff-rate quotas.

The pre-GATT policy scenario maintains price wedges between domestic and international prices by applying high tariffs, which is consistent with pre-GATT policy. Under the pre-GATT scenario, domestic farm prices are much higher than international prices, as shown in Table 7.9. The higher farm prices are quite beneficial to producers. The government of Mexico informed producers of policy prior to actual implementation, which is similar to guaranteed price supports prior to GATT. Therefore, producers had prior information of policy, implementation of tariffs was anticipated by farmers, and production decisions were adjusted accordingly beginning in 1994.

Under pre-GATT policy, area harvested increases for all crops except sorghum due to the substitution price effects of corn. The initial effect of applying tariffs under pre-GATT policy is a large increase in domestic farm prices. Corn was the most highly protected commodity prior to 1994, as shown in Table 7.10. Tariffs of 45 percent were applied to provide a price wedge between domestic and international prices similar to guaranteed price supports and quota import restrictions.

Table 7.9. Pre-GATT Mexico's average domestic farm price difference from international prices

Years	Corn	Dry Beans	Wheat	Barley	Sorghum	Soybeans
	percent					
1985-1994	92.9	31.9	39.9	70.0	45.8	44.4
1980-1994	84.2	21.7	26.3	61.5	33.0	42.5
1975-1994	72.7	12.5	16.2	46.0	55.2	35.7
1970-1994	59.8	4.2	8.9	30.1	46.9	30.3

Table 7.10. Pre-GATT policy: tariff applied to border prices

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	----	----	----	----	----	percent	----	----	----	----	----	----
Corn	45.0	45.0	45.0	45.0	45.0	45.0	27.0	27.0	27.0	27.0	27.0	27.0
Dry beans	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Wheat	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Rice	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Barley	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Sorghum	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Soybean	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Soybean meal	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Soybean meal	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Beef	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pork	20.0	18.0	16.0	14.0	12.0	10.0	8.0	6.0	4.0	2.0	0.0	0.0
Poultry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

A tariff of 30 percent was applied to dry beans, and the remaining crops have tariffs of 20 percent applied to simulate pre-GATT conditions in Mexico.

As shown in Table 7.11, harvested area increases for all crops except sorghum as producers respond to higher farm prices. Higher domestic prices make the crops are more profitable and area planted increases, with the largest increases occurring for soybeans and corn. The border price increases from 4.35 percent for wheat to 45.00 percent for corn, the most highly protected commodity. Area harvested increases by an average of 4.5 percent per year for corn from 1994 through 1999 and then by 1.9 percent per year from 2000 through 2005.

Production increases for all commodities. Soybean production increases the most among the commodities, from 20 percent to 30 percent, driven mostly by the large own-price elasticity. Sorghum production decreases for 1994-99 because of high prices for substitute crops such as corn. Consumption decreases for all the crops except food corn, which is subsidized. Mexican consumers are much worse off, facing higher prices in almost all commodities, relative to the other scenarios. Imports decrease for all the commodities except soybean oil. Corn and dry beans exhibit the largest declines (corn imports decline by 40 percent to 80 percent), and dry bean imports decrease by between 40 percent and 100 percent. Barley imports decrease by 23.5 percent in 1996 and then average a 16 percent decrease from 1997 through 2005.

Pork and poultry production decrease each year by an average of 1.5 percent and 6 percent, respectively. Meat consumption is not affected because tariffs are not applied to meat products. Decreased meat production results in large increases in imports, which average 60 percent to 125 percent for poultry.

Table 7.11. Pre-GATT policy scenario

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	Percent Change from Baseline											
Area Harvest												
Corn	4.57	4.77	4.49	4.98	4.55	4.27	1.93	1.93	1.93	1.92	1.92	1.92
Dry beans	2.27	2.99	3.10	3.43	3.07	2.99	3.02	2.96	2.95	2.95	2.95	2.95
Wheat	-0.45	-0.24	0.02	0.28	0.55	0.82	1.10	1.38	1.66	1.95	2.25	2.25
Rice	2.28	2.53	2.64	2.44	2.47	2.46	2.57	2.67	2.78	2.88	2.97	2.96
Barley	1.71	2.29	2.36	2.27	2.22	2.19	2.18	2.18	2.18	2.18	2.18	2.17
Sorghum	-4.58	-4.61	-4.40	-4.41	-4.28	-4.15	-0.21	-0.21	-0.21	-0.21	-0.21	-0.21
Soybeans	5.56	19.83	27.31	21.96	20.47	19.12	21.77	24.16	26.90	29.77	33.57	34.42
Production												
Corn	4.57	4.77	4.49	4.98	4.55	4.27	1.93	1.93	1.93	1.92	1.92	1.92
Dry beans	2.76	3.51	3.64	3.88	3.43	3.30	3.34	3.28	3.27	3.26	3.25	3.25
Wheat	0.08	0.52	0.92	1.31	1.73	2.16	2.65	3.11	3.58	4.07	4.55	4.56
Rice	2.79	3.58	3.87	3.58	3.53	3.38	3.49	3.64	3.79	3.93	4.03	4.03
Barley	1.71	2.29	2.36	2.27	2.22	2.19	2.18	2.18	2.18	2.18	2.18	2.17
Sorghum	-3.73	-2.96	-3.40	-3.60	-3.63	-3.62	0.41	0.42	0.42	0.41	0.38	0.37
Soybeans	5.56	19.83	27.31	21.96	20.47	19.12	21.77	24.16	26.90	29.77	33.57	34.42
Consumption												
Corn	-7.93	-7.52	-7.72	-8.01	-8.03	-9.65	-7.26	-6.76	-6.61	-6.53	-6.49	-6.47
Dry beans	-1.11	-1.17	-1.17	-1.45	-1.44	-1.45	-1.36	-1.37	-1.38	-1.40	-1.41	-1.42
Wheat	-0.01	-0.16	-0.34	-0.49	-0.69	-0.88	-1.21	-1.40	-1.57	-1.75	-1.92	-1.97
Rice	-0.45	-0.45	-0.44	-0.45	-0.48	-0.50	-0.54	-0.55	-0.57	-0.60	-0.62	-0.65
Barley	-2.06	-2.01	-2.06	-2.17	-2.18	-2.19	-2.20	-2.21	-2.22	-2.24	-2.25	-2.26
Sorghum	-2.59	-2.06	-2.49	-2.74	-3.05	-3.54	-4.61	-5.06	-5.35	-5.61	-5.92	-6.12
Soybeans	-3.36	-2.68	-3.00	-3.34	-3.35	-3.31	-3.40	-3.52	-3.64	-3.75	-3.89	-3.81
Soy meal	-1.91	-1.70	-2.31	-2.70	-3.13	-3.76	-4.71	-5.00	-5.29	-5.62	-6.04	-6.25
Soybean oil	-0.95	-1.17	-1.43	-1.67	-2.06	-2.54	-2.95	-3.28	-3.62	-3.96	-4.30	-4.30
Corn food	0.63	0.68	0.74	0.80	0.82	0.91	1.00	1.06	1.12	1.18	1.25	1.26
Wheat food	-0.17	-0.25	-0.33	-0.41	-0.51	-0.59	-0.68	-0.77	-0.86	-0.95	-1.04	-1.08
Corn feed	-31.65	-23.45	-25.38	-25.38	-25.57	-29.32	-22.83	-21.83	-21.82	-21.93	-21.92	-22.00
Wheat feed	2.55	1.26	-0.60	-1.92	-3.98	-6.20	-10.61	-12.08	-13.81	-15.34	-17.51	-17.09
Net Imports												
Corn	-77.42	-42.02	-84.57	-61.45	-45.46	-67.01	-85.90	-81.43	-78.47	-74.96	-69.93	-67.30
Dry beans	-44.01	-85.66	-65.58	-42.61	-77.59	-99.96	-59.76	-82.06	-96.25	-61.17	-59.22	-43.32
Wheat	-0.23	-1.57	-2.25	-3.74	-4.30	-5.09	-6.50	-7.52	-8.48	-9.43	-10.14	-10.18
Rice	-3.44	-3.87	-4.20	-4.60	-4.64	-4.47	-4.53	-4.71	-4.92	-5.09	-5.26	-5.29
Barley	-19.94	-13.40	-23.65	-19.83	-18.87	-17.45	-16.66	-15.90	-15.54	-14.99	-14.15	-13.70
Sorghum	-1.13	-0.01	-0.60	-1.10	-2.05	-3.40	-13.52	-16.36	-17.45	-18.43	-19.51	-20.14
Soybeans	-5.48	-4.77	-5.05	-4.80	-4.36	-4.24	-4.38	-4.64	-4.87	-5.08	-5.25	-5.17
Soybean meal	0.81	0.70	-0.56	-0.51	-1.82	-9.39	-25.44	-27.23	-30.40	-35.44	-45.62	-54.02
Soybean oil	9.90	10.20	5.05	5.93	7.78	7.21	4.34	0.10	-3.33	-5.98	-7.63	-7.58

Table 7.11. (continued)

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	Percent Change from Baseline											
Border Price												
Corn	45.00	45.00	45.00	45.00	45.00	45.00	27.00	27.00	27.00	27.00	27.00	27.00
Dry beans	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Wheat	4.35	5.73	7.14	8.60	10.09	11.63	13.21	14.83	16.50	18.23	20.00	20.00
Rice	9.09	10.09	11.11	12.15	13.21	14.29	15.38	16.50	17.65	18.81	20.00	20.00
Barley	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Sorghum	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Soybeans	9.09	10.09	11.11	12.15	13.21	14.29	15.38	16.50	17.65	18.81	20.00	20.00
Retail Price												
Corn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wheat	20.34	20.34	20.34	20.34	20.34	20.34	20.34	20.34	20.34	20.34	20.34	20.34
Dry beans	3.86	5.09	6.34	7.62	8.94	10.30	11.69	13.11	14.58	16.09	17.64	17.64
Rice	8.53	9.80	10.66	11.61	12.68	13.71	14.87	15.97	17.10	18.25	19.42	20.00
Production												
Beef	-1.91	-1.94	-1.40	-0.69	0.11	0.51	0.51	0.34	0.15	-0.01	-0.11	-0.17
Pork	-0.47	-0.91	-1.28	-1.40	-1.42	-1.40	-1.43	-1.47	-1.50	-1.55	-1.57	-1.58
Poultry	-4.92	-4.23	-4.79	-5.36	-5.88	-6.41	-6.79	-6.97	-7.16	-7.35	-7.52	-7.42
Consumption												
Beef	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pork	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poultry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net Imports												
Beef	97.75	45.07	-60.14	1174.06	-3.66	-22.01	-5.38	-2.02	-0.83	0.04	0.62	0.95
Pork	6.23	16.46	17.68	19.90	18.46	18.63	10.53	8.76	8.15	8.04	7.81	7.55
Poultry	62.53	65.15	61.20	64.11	77.08	84.98	107.18	102.32	97.86	99.98	116.10	125.45
Exports												
Cattle	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Border Price												
Beef	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pork	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poultry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Welfare Effects under the PROCAMPO Scenario

The welfare effects for the agricultural crops under the three scenarios—PROCAMPO, NAFTA, and pre-GATT—are provided in Tables 7.12 through 7.17. Welfare effects are presented as changes in producer and consumer surplus from the base, expressed in U.S. $1,000. The change in tariff revenue is provided for each scenario and given as the change from the base in U.S. $1,000.

Table 7.12 provides results for the PROCAMPO scenario for changes in producer surplus, consumer surplus, net welfare, and tariff revenues over the ex post, or historical, simulation period of 1994 through 1999. Ex post simulation results are useful for analysis by indicating the losses or gains that may have occurred under the alternative scenarios. Table 7.13 presents welfare and tariff revenue results for the PROCAMPO scenario throughout the forecast simulation period of 2000 through 2005.

Under the PROCAMPO scenario, tariffs are eliminated beginning in 1995 for the crop sector. The tariffs eliminated in the PROCAMPO scenario are exogenous and established as baseline tariffs, which is most consistent with the current trade policy implemented by the government of Mexico. Relative to the baseline, crop prices to producers will decrease by the amount of the tariff. The crops affected are wheat, rice, and soybeans, with tariffs of 15 percent, 10 percent, and 10 percent, respectively, in 1995. Other crops are not affected because they are not substitutes or complements to wheat, rice, and soybeans. The tariffs are eliminated throughout the simulation period of 1994 through 2005.

Initially, lower prices to producers will decrease the profitability of wheat, rice, and soybeans. Producers will decrease the area planted to these crops, as exhibited in Table 7.4. Lower prices result in a loss to producers, which is measured by a change in producer surplus from the baseline. Wheat producers with the highest tariff (15 percent) have the largest loss, as indicated in Table 7.12. Beginning in 1995, wheat producers exhibit a loss in producer surplus of $106.32 million. This loss continues throughout the historical simulation period and into part of the forecast simulation period, as presented in Table 7.13. The loss in producer surplus declines because the baseline tariff for wheat throughout the simulation period decreases to zero over the ten-year period. By 2003, the decrease in producer surplus to wheat farmers is only $7.73 million, relative to the baseline.

Under consumer surplus, most of the commodities are affected. Consumer surpluses increase for wheat, rice, and soybean oil because consumers now face a lower price as a result of the decrease in tariffs. The increase in consumer surplus is largest in 1995 and then gradually declines to zero by 2004 because the tariffs are gradually eliminated over a ten-year period in the baseline scenario. The

Table 7.12. PROCAMPO policy scenario welfare effects over historical simulation

	U.S. $1,000					
Year	1994	1995	1996	1997	1998	1999
Producer Surplus						
Corn	0	0	0	0	0	0
Dry beans	0	0	0	0	0	0
Wheat	0	-106,316	-82,499	-52,591	-36,443	-28,498
Rice	0	-9,388	-9,503	-8,677	-6,841	-5,015
Barley	0	0	0	0	0	0
Sorghum	0	0	0	0	0	0
Soybeans	0	-5,072	-3,593	-2,868	-1,740	-1,545
Consumer Surplus						
Corn food	0	-30,444	-34,056	-32,080	-34,367	-27,250
Corn feed	0	12,436	8,184	8,600	7,596	7,436
Dry beans	0	0	0	0	0	0
Wheat food	0	177,485	141,728	99,312	71,644	57,722
Wheat feed	0	12,563	9,584	5,579	4,181	3,318
Rice	0	25,558	47,837	46,828	35,903	28,800
Barley	0	0	0	0	0	0
Sorghum	0	60,172	28,343	25,466	20,945	17,988
Soybean meal	0	100,149	105,553	65,670	44,965	40,662
Soybean oil	0	39,957	35,697	39,810	28,719	21,613
Net Welfare Effect: Producer and Consumer Surplus						
Corn	0	-18,008	-25,872	-23,480	-26,771	-19,814
Dry beans	0	0	0	0	0	0
Wheat	0	83,733	68,813	52,300	39,383	32,541
Rice	0	16,170	38,334	38,151	29,062	23,785
Barley	0	0	0	0	0	0
Sorghum	0	60,172	28,343	25,466	20,945	17,988
Soybeans	0	135,034	137,657	102,612	71,944	60,730
Total Net	0	277,100	247,275	195,049	134,562	1152,31
Tariff Revenues						
Corn	0	0	0	0	0	0
Dry beans	0	0	0	0	0	0
Wheat	0	-48,514	-49,066	-29,513	-24,107	-20,383
Rice	0	-11,198	-10,962	-8,506	-6,650	-4,937
Barley	0	0	0	0	0	0
Sorghum	0	0	0	0	0	0
Soybeans	0	-61,418	-61,697	-54,766	-43,886	-38,633
Soybean meal	0	-29,166	-28,538	-14,455	-5,925	-3,170
Soybean oil	0	-4,587	-6,898	-7,095	-3,295	-1,553
Total Revenues	0	-154,883	-157,161	-114,335	-83,863	-68,675

Table 7.13. PROCAMPO policy scenario welfare effects over projected simulation

	U.S. $1,000					
Year	2000	2001	2002	2003	2004	2005
Producer Surplus						
Corn	0	0	0	0	0	0
Dry beans	0	0	0	0	0	0
Wheat	-27,344	-21,296	-14,789	-7,730	0	0
Rice	-4,284	-3,373	-2,392	-1,256	0	0
Barley	0	0	0	0	0	0
Sorghum	0	0	0	0	0	0
Soybeans	-1,142	-936	-653	-342	0	0
Consumer Surplus						
Corn food	-19,343	-15,724	-11,553	-4,000	0	0
Corn feed	6,941	5,462	3,994	2,046	1,012	602
Dry beans	0	0	0	0	0	0
Wheat food	53,664	41,301	28,463	14,768	0	0
Wheat feed	3,149	2,493	1,685	879	0	0
Rice	22,190	18,322	13,913	8,811	3001	0
Barley	0	0	0	0	0	0
Sorghum	16,633	12,642	8,587	4,473	716	105
Soybean meal	31,373	24,936	17,474	9,054	0	0
Soybean oil	17,591	14,096	9,837	5,249	0	0
Net Welfare Effect: Producer and Consumer Surplus						
Corn	-12,402	-10,262	-7,559	-1,954	1,012	602
Dry beans	0	0	0	0	0	0
Wheat	29,469	22,498	15,359	7,916	0	0
Rice	17,906	14,949	11,522	7,555	3,001	0
Barley	0	0	0	0	0	0
Sorghum	16,633	12,642	8,587	4,473	716	105
Soybeans	47,822	38,096	26,658	13,961	0	0
Total Net	99,428	77,923	54,566	31,952	4,729	707
Tariff Revenues						
Corn	0	0	0	0	0	0
Dry beans	0	0	0	0	0	0
Wheat	-19,698	-15,515	-10,901	-5,779	0	0
Rice	-4,351	-3,413	-2,410	-1,266	0	0
Barley	0	0	0	0	0	0
Sorghum	0	0	0	0	0	0
Soybeans	-30,398	-23,875	-16,653	-8,713	0	0
Soybean meal	-1,913	-1,561	-1,082	-538	0	0
Soybean oil	-1,018	-922	-771	-486	0	0
Total Revenues	-57,377	-45,286	-31,817	-16,783	0	0

Table 7.14. NAFTA policy scenario welfare effects over historical simulation

	U.S. $1,000					
Year	1994	1995	1996	1997	1998	1999
Producer Surplus						
Corn	140,011	1,876,250	46,804	436,591	819,734	294,583
Dry beans	0	74,971	178,120	229,501	27,389	7,231
Wheat	0	0	0	0	0	0
Rice	0	0	0	0	0	0
Barley	0	54,136	11,652	2,590	679	1,858
Sorghum	-25,345	-219,427	-8,590	-79,591	-118,985	-50,926
Soybeans	0	0	0	0	0	0
Consumer Surplus						
Corn food	0	12,409	30,530	63,106	7,486	73,646
Corn feed	-41,323	-607,437	-18,022	-173,094	-307,094	-162,963
Dry beans	0	-31,448	-68,839	-105,242	-9,814	0
Wheat food	0	21,247	38,325	59,551	16,876	2,870
Wheat feed	716	6,271	314	1,573	2,554	999
Rice	0	0	0	0	0	0
Barley	0	-64,983	-2,019	-103	0	-2,383
Sorghum	21,778	191,903	61,575	82,506	112,169	73,253
Soybean meal	13,117	82,341	8,818	40,522	54,779	23,593
Soybean oil	0	0	0	0	0	0
Net Welfare Effect: Producer and Consumer Surplus						
Corn	98,688	1,281,223	59,312	326,603	520,126	205,266
Dry beans	0	43,523	109,282	124,259	17,575	7,231
Wheat	716	27,518	38,639	61,124	19,430	3,869
Rice	0	0	0	0	0	0
Barley	0	-10,847	9,633	2,487	679	-526
Sorghum	-3,567	-27,524	52,985	2,915	-6,817	22,327
Soybeans	13,117	82,341	8,818	40,522	54,779	23,593
Total Net	108,954	1,396,234	278,668	557,910	605,773	261,761
Tariff Revenues						
Corn	20,389	260,008	6,528	68,639	126,315	44,069
Dry beans	0	2,847	6,975	12,637	1,147	0
Wheat	101	930	324	595	357	103
Rice	0	0	0	0	0	0
Barley	0	13,141	0	0	0	519
Sorghum	0	0	0	0	0	0
Soybeans	0	0	0	0	0	0
Soybean meal	3,263	18,465	1,184	9,583	13,126	5,395
Soybean oil	0	0	0	0	0	0
Total Revenues	23,753	295,391	15,011	91,454	140,946	50,086

Table 7.15 NAFTA policy scenario welfare effects over projected simulation

Year	2000	2001	2002	2003	2004	2005
	1,000 U.S. dollars					
Producer Surplus						
Corn	60,022	17,675	8,837	126,671	111,942	182,641
Dry beans	165,985	19,512	8,557	154,744	137,201	246,196
Wheat	0	0	0	0	0	0
Rice	0	0	0	0	0	0
Barley	2,485	3,717	3,047	3,325	875	
Sorghum	0	0	0	0	0	0
Soybeans	0	0	0	0	0	0
Consumer Surplus						
Corn food	41,055	5,247	3,083	40,092	36,896	52,749
Corn feed	-25,113	-3,885	957	1,636	253	86
Dry beans	-62,174	-7,303	-3,138	-53,230	-46,853	-80,435
Wheat food	31,422	10,313	3,551	28,478	29,813	41,414
Wheat feed	0	23	47	45	0	0
Rice	0	0	0	0	0	0
Barley	-3,224	-4,877	-4,031	-4,449	-273	0
Sorghum	29,789	13,733	9,537	6,957	512	367
Soybean meal	0	682	3,278	3,085	0	0
Soybean oil	0	0	0	0	0	0
Net Welfare Effect: Producer and Consumer Surplus						
Corn	75,965	19,037	12,878	168,399	149,091	235,476
Dry beans	103,812	12,210	5,418	101,514	90,348	165,762
Wheat	31,422	10,336	3,599	28,523	29,813	41,414
Rice	0	0	0	0	0	0
Barley	-739	-1,160	-984	-1,124	602	0
Sorghum	29,789	13,733	9,537	6,957	512	367
Soybeans	0	682	3,278	3,085	0	0
Total Net	240,249	54,837	33,725	307,354	270,365	443,019
Tariff Revenues						
Corn	0	0	0	0	0	0
Dry beans	7,388	888	394	7,177	6,554	14,440
Wheat	124	33	10	31	0	0
Rice	0	0	0	0	0	0
Barley	726	1,132	964	1,101	0	0
Sorghum	0	0	0	0	-2	-2
Soybeans	0	0	0	0	0	0
Soybean meal	-240	309	823	842	-38	0
Soybean oil	0	0	0	0	0	0
Total Revenues	7,997	2,362	2,192	9,151	6,514	14,439

Table 7.16. Pre-GATT policy scenario welfare effects over historical simulation

	U.S. $1,000					
Year	1994	1995	1996	1997	1998	1999
Producer Surplus						
Corn	899,777	1,450,572	1,102,726	895,647	785,531	809,997
Dry beans	246,172	197,780	228,497	131,206	184,494	179,614
Wheat	30,250	52,386	56,266	48,656	45,538	48,556
Rice	7,786	11,794	14,666	16,524	16,341	15,368
Barley	12,071	17,249	15,487	12,755	12,480	12,502
Sorghum	105,270	178,915	127,376	122,205	101,861	96,537
Soybeans	63,722	86,973	101,349	117,273	116,848	129,241
Consumer Surplus						
Corn food	53,547	38,265	51,976	63,106	71,361	76,114
Corn feed	-233,133	-547,460	-356,256	-336,824	-297,176	-284,573
Dry beans	-112,667	-79,836	-87,074	-62,537	-62,891	-61,707
Wheat food	-52,035	-84,322	-93,103	-88,501	-86,228	-94,725
Wheat feed	-2,448	-4,728	-4,995	-3,808	-3,832	-4,132
Rice	-20,372	-42,437	-65,336	-77,630	-74,438	-75,218
Barley	-15,004	-21,283	-19,054	-15,608	-15,422	-15,741
Sorghum	-158,754	-263,473	-185,822	-185,327	-161,172	-149,841
Soybean meal	-61,725	-88,906	-104,493	-105,506	-94,719	-98,807
Soybean oil	-15,626	-18,870	-23,348	-35,353	-34,414	-35,262
Net Welfare Effect: Producer and Consumer Surplus						
Corn	720,192	941,378	798,446	621,929	559,716	601,538
Dry beans	133,505	117,944	141,423	68,668	121,604	117,907
Wheat	-24,234	-36,664	-41,833	-43,654	-44,521	-50,301
Rice	-12,586	-30,643	-50,670	-61,106	-58,097	-59,851
Barley	-2,933	-4,034	-3,566	-2,853	-2,942	-3,239
Sorghum	-53,483	-84,558	-58,446	-63,122	-59,310	-53,304
Soybeans	-13,629	-20,803	-26,492	-23,586	-12,284	-4,828
Total Net	746,833	882,620	758,863	496,275	504,165	547,923
Tariff Revenues						
Corn	34,735	277,480	26,734	86,036	139,758	61,589
Dry beans	0	1,509	5,761	10,767	2,354	0
Wheat	12,087	22,323	30,888	24,604	27,160	31,203
Rice	8,253	12,680	15,297	14,679	14,489	13,928
Barley	2,071	5,309	2,449	2,539	2,636	2,929
Sorghum	53,441	86,211	58,513	62,955	58,890	52,633
Soybeans	39,389	68,553	84,761	94,203	96,026	109,345
Soybean meal	7,869	14,344	18,760	12,937	7,001	4,489
Soybean oil	3,875	2,902	5,179	7,221	4,597	2,886
Total Revenues	161,719	491,311	248,342	315,943	352,910	279,002

Table 7.17 Pre-GATT policy scenario welfare effects over projected simulation

	U.S. $1,000					
Year	2000	2001	2002	2003	2004	2005
Producer Surplus						
Corn	544,082	557,034	577,040	594,498	607,457	621,283
Dry beans	178,439	187,004	193,002	198,560	203,759	209,559
Wheat	65,244	75,013	85,708	97,508	104,135	108,730
Rice	17,495	19,510	21,971	24,352	26,639	28,098
Barley	12,535	12,487	13,069	13,407	13,562	13,912
Sorghum	115,872	123,721	129,602	135,775	140,222	143,963
Soybeans	138,751	157,162	175,144	195,426	215,584	221,774
Consumer Surplus						
Corn food	78,551	82,824	89,068	96,525	105,203	114,657
Corn feed	-183,856	-187,188	-191,786	-196,537	-202,586	-206,752
Dry beans	-66,425	-66,301	-66,693	-67,316	-68,263	-69,054
Wheat food	-123,287	-140,060	-158,793	-179,304	-194,127	-201,630
Wheat feed	-5,583	-6,634	-7,462	-8,573	-8,815	-9,650
Rice	-77,054	-87,076	-98,431	-110,294	-121,661	-130,726
Barley	-15,980	-16,135	-17,011	-17,652	-18,191	-18,877
Sorghum	-170,537	-178,172	-185,432	-193,048	-198,541	-203,462
Soybean meal	-101,257	-112,965	-124,798	-137,207	-148,738	-151,743
Soybean oil	-40,158	-47,503	-54,541	-63,347	-73,134	-77,563
Net Welfare Effect: Producer and Consumer Surplus						
Corn	438,777	452,671	474,321	494,486	510,074	529,187
Dry beans	112,013	120,704	126,310	131,244	135,496	140,505
Wheat	-63,626	-71,680	-80,547	-90,369	-98,808	-102,550
Rice	-59,558	-67,566	-76,460	-85,942	-95,023	-102,627
Barley	-3,445	-3,648	-3,943	-4,245	-4,629	-4,965
Sorghum	-54,665	-54,452	-55,830	-57,273	-58,320	-59,498
Soybeans	-2,664	-3,306	-4,195	-5,128	-6,288	-7,532
Total Net	366,833	372,723	379,657	382,774	382,504	392,519
Tariff Revenues						
Corn	9,052	11,907	14,600	18,202	23,976	27,720
Dry beans	5,700	1,937	359	5,967	6,722	13,015
Wheat	41,696	48,258	55,604	64,002	0	0
Rice	16,419	18,267	20,502	22,763	24,830	26,300
Barley	3,132	3,333	3,610	3,901	4,277	4,600
Sorghum	51,250	49,955	50,747	51,729	52,230	53,061
Soybeans	114,932	127,913	141,776	156,698	172,368	176,859
Soybean meal	2,841	3,488	3,939	4,096	3,509	2,853
Soybean oil	2,522	3,180	4,199	5,612	7,605	9,431
Total Revenues	247,543	268,237	295,338	332,969	295516	313,840

largest increases in consumer surplus are for food wheat, rice, and soybean oil, at $177.48 million, $25.55 million, and $39.95 million, respectively. Only corn consumed as food has a decrease in consumer surplus throughout the simulation. The corn retail price is not affected. However, wheat is a substitute in the corn food demand equation, so a decrease in wheat price will cause consumers to switch to wheat, thereby shifting the corn demand equation to the left and resulting in a decrease in the consumer surplus for corn. The consumer surplus for food corn decreases by $30.44 million in 1995, which is a relatively small amount considering that corn is the staple food of Mexico. The consumer surplus loss for corn for food consumption gradually becomes smaller until its only a $4 million decrease relative to the baseline in year 2003.

All the feed demand equations are affected, resulting in increases in consumer surplus for feed wheat, soybean meal, sorghum, and feed corn. Decreases in the price of feed wheat and especially in the price of soybean meal to the pork and poultry industries result in increased demand for these commodities. The lower prices result in increased consumer surpluses for soybean meal and feed wheat of $100.14 million and $12.56 million, respectively, in 1995. The increases in consumer surplus for these commodities gradually decline as baseline tariffs are decreased.

Feed corn and sorghum are also affected. Both have an initial decrease in demand because of lower prices for soybean meal and wheat, given that the latter are substitutes. However, increased pork and poultry production increases demand for feed corn and sorghum, which results in an increase in consumer surplus throughout the simulation. In 1995, the increased consumer surpluses for feed corn and sorghum are $12.43 million and $60.17 million. Very little corn is used for livestock feed in Mexico, but almost all sorghum is used for livestock feed, which explains why the sorghum consumer surplus is almost five times larger than feed corn consumer surplus.

The net welfare effect for the PROCAMPO scenario presented in Tables 7.12 and 7.13 is positive for all crops except corn. The increase in consumer surpluses for wheat, rice, and soybeans are larger than the decrease in producer surplus for all years in the simulation. Increased pork and poultry production results in increased consumer surpluses for feed corn and sorghum. Only food corn consumption has a negative welfare effect throughout the simulation period. As noted, only a small amount of corn is used for livestock feed in Mexico, which explains why the feed corn consumer surplus is smaller than food corn consumption.

The total net welfare effect is positive throughout the simulation and is driven by increased consumer surpluses in both the food grain and feed grain industries. In 1995, the increase in total welfare is $277.1 million, which gradually declines to an increase of $7.07 million by 2005.

The government of Mexico implements a decrease in tariff revenues for wheat, rice, soybeans, soybean meal, and soybean oil. Corn, dry beans, barley, and sorghum do not have tariffs applied in the baseline; therefore, changes in imports for these commodities do not affect tariff revenue to the government of Mexico. Total tariff revenue decreases by $154.88 million in 1995 and gradually declines to zero by 2004. In the baseline, all tariffs decrease to zero by 2004.

Welfare Effects under the NAFTA Scenario

The NAFTA welfare analysis and changes in tariff revenues are listed in Table 7.14 for the historical simulation period 1994-99 and in Table 7.15 for the forecast simulation period 2000-05. In the NAFTA scenario, only tariffs are applied to commodities with imports above the tariff-rate quota.

The crops with tariff-rate quotas are corn, dry beans, and barley, and producer surpluses are positive for these crops. Corn has the largest gain in producer surplus, averaging $344 million, and exhibits the largest quantity of imports above the quota prior to application of the tariff. The increase in producer surpluses for dry beans and barley average $104 million and $77 million, respectively. In 1994, the dry beans and barley producer surpluses did not change because imports were less than the quota and a tariff was not applied. Sorghum exhibits a decrease in producer surplus from 1994 through 1999 because sorghum and corn are substitute crops and therefore a large increase in corn price will shift more profitable land away from sorghum and into corn production. Also, more progressive and profitable producers will usually switch to the most profitable substitute crops, which leaves less efficient farms producing the less profitable crops. The tariff on corn is only applied from 1994 through 1999, which explains why sorghum exhibits a decrease in producer surplus in those years.

The consumer surpluses decrease for feed corn, dry beans, and barley in the years a tariff is applied. The average decrease in consumer surpluses for feed corn, dry beans, and barley throughout the simulation are $111 million, $39 million, and $72 million, respectively. Food corn shows an increase in consumer surplus because it is assumed that the retail price for corn is subsidized by the government and is not responsive to tariffs or changes in international price. In addition, an increase in the dry bean price will cause a substitution away from dry beans and toward corn. This substitution will shift out feed corn demand, which results in an increase in consumer surplus when corn retail prices are held constant.

The average increase in the food corn consumer surplus is $30 million per year. Sorghum and soybean meal exhibit an increase in consumer surplus because the increase in corn price for feed leads to substitution away from corn and toward sorghum and soybean meal. In addition to substitution, there is increased feed demand because of increased poultry production.

The net welfare effect is positive for most crops, but for varying reasons. Corn, dry beans, and barley have increased producer surpluses that are greater than the decrease in consumer surpluses. Only sorghum exhibits a negative producer surplus that is less than the increase in the sorghum consumer surplus. Total net welfare is positive and averages $380 million throughout the simulation.

Changes in tariff revenue for the NAFTA scenario are presented in Tables 7.14 and 7.15. The tariff revenues for corn, dry beans, and barley are zero in some years because the tariff is applied only when imports were greater than the tariff-rate quota. The tariff is then solved for within the model, resulting in imports equal to or slightly less than the quota. The average tariff revenues for corn, dry beans, and barley are $44 million, $5 million, and $1.5 million, respectively. Soybean meal also exhibits an increase in tariff revenue because a tariff is applied in the baseline and import demand for soybean meal increases. The total tariff revenue averages $55 million throughout the simulation.

Welfare Effects in Pre-GATT Scenario

The pre-GATT welfare analysis and changes in tariff revenues are presented in Tables 7.16 and 7.17 for the historical and forecast simulations of the pre-GATT scenario, respectively. The pre-GATT scenario assumes that NAFTA, GATT, and PROCAMPO do not exist, and tariffs are applied to maintain a price wedge between domestic and international prices similar to policies that existed prior to 1994. Prior to GATT, NAFTA, and PROCAMPO, Mexico implemented quotas to protect the major crops from imports and the domestic market was supported above international prices. The tariff applied to corn is 45 percent from 1994 through 1999 and 27 percent from 2000 through 2005. Dry beans have a tariff of 30 percent applied throughout the entire simulation of 1994 through 2005. The remaining commodities—wheat, rice, barley, soybeans, and sorghum—each have tariffs of 20 percent applied throughout the simulation period.

As shown in Table 7.16, pre-GATT policies benefit all producers, as indicated by positive producer surpluses for all the crops. Producers benefit because the prices received for crops increases for all commodities. Tariffs provide a price wedge between domestic and international prices, which is similar to pre-GATT conditions when price supports were maintained above international prices and imports were restricted by quotas.

The producer surpluses are largest for corn and dry beans, which are the two most important commodities for food consumption in Mexico. In 1994, the change in producer surplus from the baseline for corn is an increase of $899.77 million. Corn is the most highly protected crop in Mexico and also covers the largest crop area by slightly more than four times compared to area devoted to dry beans and sorghum, the next largest crops. The forecast simulation increase in corn producer surplus averages $585 million, with the lowest surplus in 2000 ($544 million) and the highest in 2005 ($621 million). No distinct trend exists for the change in producer surplus in corn except that, beginning in 2000, the tariff is reduced to 27 percent. The commodities with the second, third, and fourth largest increases in producer surplus are dry beans, soybeans and sorghum, which average $195 million, $143 million, and $127 million per year, respectively. Wheat, rice, and barley exhibit average increases in producer surplus of $68 million, $18 million, and $14 million, respectively, over the simulation period. The only distinct trend in producer surpluses is an increase for commodities that have tariffs applied under the baseline, such as wheat, rice, and soybeans.

Changes in consumer surpluses are negative for all commodities except food corn, which has a positive change from the baseline. This change is positive because it is assumed that the government continues to subsidize tortillas to consumers and that a large amount of corn is consumed on the farm and not marketed. Therefore, the retail price is not linked to either the international price or the farm price. Thus, as wheat and dry bean prices increase, corn demand will shift out because corn is a substitute for these commodities, resulting in an increase in consumer surplus. The consumer surplus for corn is $53.54 million, which increases throughout the simulation and reaches $115 million by 2005, relative to the baseline. The consumer surplus for wheat increases because decreasing tariffs in the baseline cause the wheat price increase to be larger than in 1994. For example, the 20 percent tariff applied under the pre-GATT scenario is only 5 percent greater than the 15 percent tariff applied in 1994 under the baseline scenario. By 2004, the 20 percent tariff applied under the pre-GATT scenario is a 20 percent increase in price because the baseline wheat tariff is zero in 2004.

All the commodities except corn for food consumption exhibit a decrease in consumer surplus relative to the baseline. Tariffs cause all prices except the retail corn price to increase, resulting in decreased demand and a decrease in consumer surplus. The decrease in the consumer surplus for corn utilized as feed is shown in Table 7.16. Feed corn demand has a large own-price elasticity, which causes large fluctuations in demand. Also, corn has the highest tariff, at 45 percent. The government of Mexico does not subsidize feed corn, so most of the tariff is passed on to pork and poultry producers in the form of higher feed costs, which results in a large decrease in demand for feed corn. The decrease in the consumer surplus for feed corn in 1994 is $233 million. The average decrease in consumer surplus for feed corn throughout the simulation is $268 million. The second and third largest decreases in consumer surplus are for sorghum and food wheat, which average a decreases from the baseline of $186 million and $132 million, respectively.

The net welfare effect is positive for corn and dry beans throughout the simulation period. The producer surplus is large for both commodities, and the consumer surplus is positive for corn and relatively small for dry beans. Consumer surplus is positive because the government subsidizes corn for food consumption. The decrease in dry bean consumer surplus is relatively small because of the small price elasticity in dry bean demand and small price transmission. A large quantity of dry beans is consumed on the farm. The average net welfare effect throughout the simulation for corn and dry beans is $595 million and $122 million, respectively, per year. The net welfare effect is negative for wheat, rice, barley, sorghum, and soybeans, and the loss in consumer surplus is larger than the gain in producer surplus for each of these commodities. The total net welfare effect is positive throughout the simulation because the corn and dry beans producer surpluses are positive and quite large. The government of Mexico is incurring the cost of this program. As shown in Tables 7.16 and 7.17, tariff revenues are largest for corn, soybeans, and sorghum. Total tariff revenues average $300 million throughout the simulation period.

CHAPTER 8. SUMMARY AND CONCLUSION

This study develops an econometric supply and demand model of Mexico's crop and livestock sectors that is used to analyze alternative trade policies. The primary objective of this study is to analyze the effects of changing agricultural and trade policies in Mexico on production, consumption, and trade in the grain and livestock sectors. Policy instruments for Mexico's liberalization polices in domestic agriculture and international trade are incorporated with the international market through price linkages. International agricultural trade for Mexico is analyzed by deriving net import identities for the different crop and livestock sectors.

Mexico's domestic agricultural and trade policy has been implemented to provide a gradual alignment of the domestic market with international markets. Current trade policies in Mexico are a mixture of GATT, NAFTA, and PROCAMPO, which overlap to some degree. No one specific trade policy agreement or domestic policy program dominates Mexico's current domestic and trade policy position. The government has implemented NAFTA for soybeans, wheat, rice, and hogs and pigs. Complete liberalization is implemented for corn, dry beans, and sorghum, which is consistent with PROCAMPO. NAFTA provides for complete liberalization of sorghum. GATT tariff rates have not been applied to trade for some commodities from the United States and Canada (which is in violation of the NAFTA agreement), but tariff rates have been applied to imports from other countries—especially for wheat—which provides NAFTA partners with a trade advantage. This research makes the point that policy analysis of only one trade agreement or domestic policy agenda may provide unrealistic assessments of current economic conditions.

This study is organized into eight chapters. Chapter 1 presents the research problem and objective of the study. Chapter 2 presents the crop and livestock sectors incorporated into the agricultural model for Mexico. The seven grain crops included in the model are corn, wheat, dry beans, rice, sorghum, soybeans, and barley, and the three livestock sectors included in the model are cattle, hogs and pigs, and poultry. Production, consumption, trade, and the relative importance to agriculture in Mexico are presented for each commodity.

Chapter 3 presents Mexico's agricultural policy, trade, and marketing systems. Agricultural policy for Mexico is reviewed, including recent domestic policies under PROCAMPO, international trade policy under GATT and NAFTA, and relevant U.S. policy. As discussed in Chapter 3, the three major policy programs evolved as follows.

PROCAMPO, a domestic support program for the Mexican farm sector, was announced on October 4, 1993, by President Carlos Salinas de Gortari and was recognized as a permanent institution by

President Ernesto Zedillo under the Rural Alliance program, announced on October 31, 1995 (USDA 1995). The program will gradually align domestic prices with international prices, and direct income support is made eligible to producers as compensation for low prices. The crops included under PROCAMPO are corn, dry beans, wheat, sorghum, rice, soybeans, barley, safflower, and cotton. PROCAMPO replaced the previous system of price supports and direct payments with a completely decoupled direct income support program to producers and thus does not distort production decisions and trade.

The Uruguay Round of the GATT negotiations was initiated in 1986 and was signed by 111 countries on April 15, 1994. The significance of the agreement is the inclusion of agriculture, which had not been dealt with in detail in earlier GATT rounds. During the Uruguay Round, negotiators recognized that domestic agricultural policies affect border measures and needed to be dealt with. Agricultural policies in the Uruguay Round agreement are built around four areas that distort international trade: market access, internal support, export subsidies, and sanitary and phytosanitary barriers.

NAFTA was signed in December 1992, ratified by the U.S. Congress in December 1993, and implemented on January 1, 1994. NAFTA will lead to the establishment of a free trade area among the United States, Mexico, and Canada. The free trade area requires the elimination of all tariff and nontariff barriers to trade between participating countries while maintaining independent trade policies with nonparticipating countries.

Chapter 4 reviews economic research on Mexico's agricultural economy, focusing on domestic and international trade policy. The chapter reviews previous agricultural models for Mexico, including models for Mexico's domestic economy, agricultural sector, and specific studies on the livestock and grain sectors. The chapter also presents results from previous studies on the effects of GATT and NAFTA on the U.S. and Mexican agricultural sectors. As discussed, numerous modeling procedures, such as econometrics, computable general equilibrium, linear and nonlinear programming, and social accounting matrix, under partial and full equilibrium, have been used to analyze Mexico's agricultural economic policies. Previous research has focused on a variety of issues, including domestic agricultural policy, structural and technological change, land tenure and reform, green revolution and production, and labor migrations. More recent studies have focused on domestic agricultural policy and trade policy issues, with a large number analyzing NAFTA policy and liberalization of Mexico's agricultural policy. As noted in Chapter 4, major differences in results in previous studies have occurred as a result of different levels of specification detail in the agricultural sectors and incorporation of policy instruments.

Both partial and general equilibrium models give similar results when specification is modeled in detail, whereas both types of models perform poorly when specification structure is highly aggregated.

Chapter 5 presents the rationale for determining which modeling technique is most appropriate for this research problem. For example, the chapter discusses the positive and negative aspects of a partial equilibrium as compared to a full equilibrium model, an econometric model versus a computable general equilibrium model, or nonlinear programming models. The chapter reviews previous agricultural policy literature and determines which theoretical approach is most appropriate in deriving supply and demand relationships for Mexico's agricultural sectors. Issues concerning the appropriate model include recent economic theory for domestic policies and trade policies that affect price supports and tariffs.

The model developed for Mexico in this study is a nonspatial multimarket dynamic partial equilibrium econometric simulation model consisting of seven agricultural sectors and three livestock sectors. The crop commodities modeled are corn, dry beans, wheat, rice, barley, sorghum, and soybeans. The livestock commodities are beef, pork, and chicken. Domestic and international agricultural policy instruments for PROCAMPO, NAFTA, and GATT are incorporated. As noted in Chapter 5, Mexico is not a large importer on the world market and is assumed to have no impact on world prices. Therefore, Mexico is assumed to be a small country and price taker in international trade.

Chapter 6 presents the estimation results and simulation, including data sources and the data used in this analysis. Specifics of estimating the model are presented, including the appropriateness of using a specific estimator and its properties. The elasticities for different commodities are presented, along with the estimated model, coefficients, basic statistics, and model validation. Chapter 6 also presents a simulation of the statistical results for the period estimated. Graphs of actual and simulated values of key economic variables are presented for comparison.

The crops are specified according to the biological nature of production. Price and quantity are not simultaneously determined because of government price support policies and the use of quotas to restrict imports. The estimated parameters, t-statistics, time period used for estimation, R^2 and adjusted R^2 statistics, standard error, Durbin-Watson, and mean of estimated variables are provided.

The food grains included in the model are corn, dry beans, wheat, rice, soybean oil, and barley. The equations are estimated using OLS. All food consumption equations are estimated as per capita consumption. Total food consumption is derived from the identity of population times per capita consumption. Dry beans, rice, barley, and soybean oil are used only as food for human consumption in the model. Corn and wheat also have feed demand equations, which are presented.

Simulation statistics are presented for the period 1975-95. The model is validated using simulation statistics and by calculating dynamic multipliers and is found to provide reasonable simulation results and to be dynamically stable.

A number of alternative functional forms are estimated for the grain feed and food demand equations in the model. The estimated parameters from these functional forms are not the expected sign or size, as suggested by economic theory for food consumption in Mexico. The estimated parameters were quite sensitive to functional form and choice variables, even though economic theory suggests which variables should be included. The statistical significance of the variables is quite low. These functional forms have been applied in modeling numerous other countries with satisfactory results. The demand function initially estimated is a popular functional form that satisfies the properties of demand systems, or the Almost Ideal Demand System. Additional demand systems estimated include a double-logarithmic demand system incorporating Stone's price index, which satisfies properties of adding up and homogeneity. A double-logarithmic demand system that does not incorporate Stone's price index but that satisfies homogeneity restrictions is also estimated. All alternative demand systems provide unsatisfactory results with respect to price and income elasticities.

Chapter 7 presents a discussion of the baseline development and incorporation of policies and policy instruments. The baseline projection is presented, as is the evaluation of alternative policy scenarios for NAFTA, pre-GATT, and PROCAMPO policies and a currency devaluation. These scenarios are evaluated and compared to the baseline.

Continued gradual elimination of trade barriers is the most likely trade policy that the government of Mexico will maintain in the future and is consistent with the baseline used in this research. The second most likely trade policy is complete liberalization, which is consistent with the PROCAMPO scenario. The third option is a more conservative policy position that increases import restrictions for corn and dry beans. This option is consistent with NAFTA trade policy that implements tariff rate quotas. Financial difficulties among lower-income producers may influence the government of Mexico to continue to protect the corn and dry bean sectors, but the government has helped alleviate this problem by providing payments to producers that are decoupled from production decisions. The least likely trade policy option and the most politically and financially difficult to justify and support would be a return to highly protected domestic agricultural markets with producer price supports. The highly protected market would be consistent with policy enacted prior to GATT and is similar to the pre-GATT scenario presented in this study.

Complete liberalization of Mexico's agricultural sector would not be difficult for the government of Mexico at this time. Only three of the seven crops analyzed have trade protection. Wheat, rice, and soybeans have tariffs of 6 percent, 4 percent, and 4 percent respectively, in 2000. According to the results of this study, complete liberalization would not have large effects on Mexican agriculture. Wheat, rice, and soybean production would decline by 1.83 percent, 0.69 percent, and 7.02 percent, respectively, beginning in 2000, with zero percent decreases by 2004. The large decrease in soybean production is questionable because of the large estimated supply response. Other crops, such as corn and dry beans, would not be affected by production declines for wheat, rice, and soybeans because they are grown in different geographic regions. Production decreases in 2000 are 61,000 metric tons for wheat, 2,000 metric tons for rice, and 11,000 metric tons for soybeans.

Consumption would change by less than 1 percent for most crops under complete liberalization. Wheat utilized as feed has the greatest increase (7.98 percent) in 2000, which is equivalent to an increase of 24,000 metric tons. Pork and poultry production increase by 0.59 percent and 1.15 percent, or 6,000 metric tons and 20,000 metric tons, respectively. The net welfare effects for wheat, rice, and soybeans increase by U.S. $29.4 million, $17.9 million, and $47.8 million, respectively. The total net welfare effect increases by $99.43 million. Tariff revenues lost to the government of Mexico total $57 million in 2000.

In the second scenario, the government of Mexico increases trade restrictions in accordance with NAFTA agreement. This can only be accomplished by implementing tariff-rate quotas on corn, dry beans, barley, and poultry. The tariff levels allowed under NAFTA in 2000 are sufficiently large to restrict imports to quota levels. The maximum allowable tariffs in 2000 for corn, dry beans, barley, and poultry are 145 percent, 94 percent, 61 percent and 79 percent, respectively. Under the NAFTA scenario, tariffs were applied to corn imports from 1994 through 1999 because imports are greater than the quota established under NAFTA during that period. Results from the NAFTA scenario indicate that producers will respond to higher prices and corn production will increase significantly.

In 2000, a tariff is applied to dry beans because imports are greater than the tariff-rate quota established under NAFTA. The tariff leads to increased production of 2.66 percent, or 35,000 metric tons. Imports decrease by 47,000 metric tons, to the tariff quota level. In the forecast period, tariffs are small for barley and poultry but high for dry beans. The net welfare effect continues to be positive throughout the NAFTA scenario because the producer surplus and increase in consumer surplus for substitute crops are larger than the negative consumer surplus caused by higher tariffs.

The least likely policy position for Mexico would be a return to pre-GATT policies. This trade position would require domestic price supports and import trade restrictions and would be a direct violation of GATT and NAFTA. Perhaps the most serious implications would be the resulting political problems for the government of Mexico. The government would incur large financial debt and most likely would be unable to finance these programs. Under the pre-GATT scenario, consumer surplus is negative for all crops except corn, which needs to be strongly subsidized by the government. The consumer surplus for corn is relatively small compared to total consumer loss. Pre-GATT policies were abandoned in part because the government of Mexico was unable to support the large government debt incurred to support these policies.

Given the results of this analysis, further research would be quite beneficial in a number of areas. Detailed analysis of the individual crops under study would provide useful information as producers respond to a more competitive environment with little government intervention. Studies analyzing changing food demand—especially for staple foods such as corn, wheat, and dry beans—would be beneficial. Research into the corn and dry bean sectors utilizing household models and detailed data would provide valuable information about how subsistence households are responding to liberalized markets. Household models would provide information on consumption and production responses to market prices and trade policies for corn and dry beans, the major food staples in Mexico.

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ACKNOWLEDGMENTS

I would like to express my sincere thanks and appreciation for the support, patience, and guidance received throughout the completion of my dissertation from my major professor, Dr. William H Meyers. I am also grateful to the members of my committee: Dr. Marvin L Hayenga, Dr. Wallace E. Huffman, Dr. Paul W. Gallagher, and Dr. Yasuo Amemiya.

Finally, I want express my deepest thanks to my mother and father for their support and love, to Lila Joyce Hansen, and to Robert Hans Hansen. Not a day of my life passes by without thoughts and fond memories of family—Mom, Dad, Robert, Jenneane & Mike, and Steve. Yes, I know this hard to believe, since all cards ever sent are always very late and have often been lost in the mail.