U.S./MEXICO RICE TRADE:
AN ECONOMIC ANALYSIS OF
FACTORS INFLUENCING FUTURE TRADE

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ABSTRACT:

This study examines the effects on U.S. rough, brown and white long-grain rice exports to Mexico that result from removal of Mexico's rice tariffs in 2003 and from Mexico's acceptance of long-grain rice imports from Thailand. The study objectives are accomplished with a model of the long-grain rice market that allows for predictions to be made about the effects of trade policy changes on rice in its various forms (white, brown, rough). Mexico's removal of its rice tariffs would modestly influence the U.S. rice economy, alter the form of U.S. rice marketed to Mexico from rough rice to white rice, and profoundly impact the Mexican rice economy. Thailand is a potential threat to the U.S.'s current dominance in the Mexican rice import market, particularly if historically high U.S./Bangkok price spreads and comparatively low Thailand-to-Mexico ship rates were to occur. Mexico's tariffs on rice imports from Thailand are important in preserving the U.S. role in the Mexican rice market.

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EXECUTIVE SUMMARY

This report is the second of two on the Mexican rice market prepared for the U.S. Rice Producers Association by the Texas Agricultural Market Research Center. This first report explored and analyzed the structure of the Mexican rice market and derived implications to guide strategic planning. That report also served as background to this study, an in-depth statistical assessment of the logistics and transportation system for U.S.-Mexico rice trade and the impact that changes in Mexican tariffs will have on that trade. Together, the two reports provide important insights on the opportunities and challenges for future growth of U.S. rice exports to Mexico, particularly with the potential for NAFTA-induced tariff reductions to alter the competitive position of U.S. rice in Mexico.

A number of critical factors must be considered in analyzing the transportation of U.S. rice to Mexico, including trade barriers, Mexican milling capacity and costs relative to those the U.S., costs of alternative modes of transportation, etc. For example, Mexico's existing tariff schedule favors the import of rough rice. Some believe that the increase in U.S. rough rice exports to Mexico since 1994 stems from the uneven tariffs. Others argue that excess milling capacity in Mexico that results from declining rice production has provided the principal impetus for Mexico's import of rough rice. With removal of all Mexican import tariffs in the year 2003, a variety of economic forces will be initiated that may alter the mix of U.S. rice products imported by Mexico. The future mix of rice products imported by Mexico would seem to be impacted by milling costs in the United States and Mexico, farm production trends in Mexico, transport costs associated with U.S. exports of rough, brown and white rice to Mexico, and rice by-product prices in the two countries.

Mexico's restrictions on Asian rice imports also influence the pattern of rice trade. In 1992, Mexico banned imports of Asian rice as a result of phytosanitary concerns. Prior to that time, Asia supplied a significant share of the Mexican rice market. Although Asian rice exporters are no longer explicitly banned, they are obligated to show that their rice is free of selected pests and produced in a region without a history of those pests. No Asian rice exporting nation has met this qualification yet. However, some believe Thailand will eventually become eligible to reenter the Mexican market and displace or severely reduce the U.S. role in that market. Thailand traditionally competes with the U.S. in high-quality, long-grain rice markets with its 100%, Grade B long-grain rice which is viewed as a close substitute for the U.S. No. 2 long-grain, 4% broken product.

The objectives of this study are to: (1) estimate the effect on U.S. rough, brown and white long-grain rice exports to Mexico that result from removal of Mexico's rice tariffs in 2003 and (2) estimate the effect on U.S. rough, brown and white long-grain rice exports to Mexico that would result from Mexico's acceptance of long-grain rice imports from Thailand. To accomplish the objectives a

spatial equilibrium, multi-product model that includes the long-grain rice sectors of both the U.S. and Mexico was specified and estimated. The model allows for predictions to be made about the effects of trade policy changes on trade in rice in its various forms (white, brown, rough). U.S. and Mexico rice production, consumption, transportation and logistics charges, and Mexican tariffs are developed to be representative of the latter 1990s. The features of the model include:

- 17 rough rice supply regions in the U.S.
- 9 white and brown rice demand regions in the U.S.
- 8 rice milling sites in the U.S.
- 4 port areas, 8 barge-loading sites in the U.S.
- 6 border-crossing locations
- 9 rough rice supply regions in Mexico
- 9 white rice demand regions in Mexico
- 12 rice milling sites in Mexico
- 2 port areas in Mexico
- Numerous rail, truck, barge and ship transportation links for rough, brown and white rice
- Demand faced by the U.S. from the rest of the world
- Excess supply for Thailand's high-quality long-grain rice

The solution of this model serves as a base or reference point in the analysis. Model validation was successful, and the developed model was used to evaluate the influence of zero Mexican rice tariffs in 2003 and the effect of removing Mexico's ban on imported Thailand rice.

The results suggest that elimination of the Mexican rice tariffs in 2003 (free trade) would have a modest influence on the U.S. rice economy, provide impetus to alter the form of U.S. rice marketed to Mexico, and profoundly impact the Mexican rice economy. Removal of Mexico's rice tariffs would also increase U.S. long-grain rice exports to Mexico, increase rice prices in the United States and lower rice prices in Mexico. Average long-grain producer prices in the United States are projected to increase from $178.82/ton (base model) to an estimated $180.43/ton with removal of all Mexican tariffs, a 0.9% increase in U.S. price. The higher prices modestly increase U.S. long-grain production from 6.256 to 6.262 million tons. Revenues of U.S. producers increase from $1.12 billion to $1.13 billion, about a 1.0% increase. Higher prices are also reflected at the packer level where prices increase about 0.7%. The higher prices modestly discourage U.S. long-grain, white rice consumption, which declines from an estimated 2,027.6 to 2,025.3 thousand tons.

Removal of Mexican rice tariffs is projected to have an important influence on the form that U.S. rice is exported to Mexico. In the base model, most U.S. long-grain rice was exported to Mexico as rough rice. However, after removal of all tariffs, exports are in the form of white rice. In particular, white rice exports to Mexico are projected to increase from 0.3037 million tons (milled basis using Mexico conversion of 0.68) to 0.3254 million tons, a 7.1% increase in U.S. exports to Mexico. Transportation costs and higher financial costs in Mexico favor U.S. exports of white rice over rough rice.

The relatively high tariff on white rice imports *ex ante* Mexico's tariff removal was apparently central to Mexico's import of rough rice since, after the removal of these tariffs, Mexico became an importer of white rice. Relative milling charges in the two countries as well as transportation, handling and financial costs, and by-product prices determine location (United States versus Mexico) of the milling activity. However, white rice exports to Mexico are not sensitive to lower milling charges in Mexico *ex post* tariff removal.

The analysis of Thailand's potential role as a competitor of the U.S. in the Mexican rice market is based on the assumption that NAFTA provisions have been fully implemented, i.e., Mexican rice tariffs do not apply on imports from the United States, whereas Mexican tariffs may be applied to imports from Thailand. Mexican tariffs on imports of Thailand rice have an important influence on Mexican production and price as well as U.S. rice price. Additional analysis suggests Thailand is a modest threat to the U.S.'s current dominance in the Mexican rice import market. Only at historically high U.S./Bangkok F.O.B. port price spreads and comparatively low Thailand-to-Mexico ship rates would Thailand have a presence in the Mexican market. The U.S. role in the Mexican market could be preserved if Mexico were to levy at least a 10% *ad valorem* tariff on any potential Thai imports.

In summary, rice provisions of NAFTA have a positive influence on U.S. rice producers and millers by increasing U.S. producer prices and revenues and providing impetus for increased milled rice exports to Mexico. The analysis suggests Thailand is a moderate threat to U.S. dominance of the Mexican rice market.

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Mexico has become the largest importer of U.S. rice (>$90 million/year) in the western hemisphere and the second or third largest importer of U.S. rice in the world (www.fas.usda.gov). Since the late 1980s, U.S. rice exports to Mexico have nearly quadrupled (USDA, *Rice Situation and Outlook Yearbook*). This is attributed to Mexico's growing population, reduced Mexican rice tariffs, declining Mexican rice production and Mexico's ban on Asian rice imports after 1992, thus allowing the United States to capture nearly all of this growing market. This study examines the effects of Mexico's declining rice tariffs and the anticipated removal of the Asian rice import ban on U.S. rice exports to that country.

Historically, Mexico provided important input and price subsidies to its crop sector and protected its producers through a rigid system of tariffs and quotas. In 1986, Mexico joined the General Agreement on Tariffs and Trade (GATT), thus initiating a major reorientation in trade policy. In 1994, Mexico entered into the NAFTA (North American Free Trade Agreement) and committed itself to reductions in rice tariffs with removal of all rice tariffs scheduled for January, 2003. Prior to 1994, Mexico had levied a 10 percent *ad valorem* tariff on rough rice imports and a 20 percent *ad valorem* tariff on brown and white rice imports. Under the provisions of NAFTA, Mexico will reduce the *ad valorem* tariff on rough rice by 1 percentage point per year, and will reduce the *ad valorem* tariff on processed rice (brown and white rice) by 2 percentage points per year. These scheduled reductions will lead to a removal of all tariffs in January, 2003. Clearly, Mexico's tariff schedule favors the import of rough rice and some believe the increase in U.S. rough rice exports (135% increase) since 1994 stems from the uneven tariffs. Others argue that excess milling capacity in Mexico that results from declining rice production has provided the principal impetus for Mexico's import of rough rice. With removal of all tariffs in 2003, a variety of economic forces will be initiated that may alter the mix of U.S. rice products imported by Mexico. The future mix of rice products imported by Mexico would seem to be impacted by milling costs in the United States and Mexico, farm production trends in Mexico, transport costs associated with U.S. exports of rough, brown and white rice to Mexico, and rice by-product prices in the two countries.

An additional issue influencing the future of U.S. rice exports to Mexico is its restriction on Asian rice imports. In 1992, Mexico placed a ban on imports of Asian rice as a result of phytosanitary concerns (Conlon). Prior to this time, Asia supplied a significant share of the Mexican rice market. In reaction to obligations imposed by the World Trade Organization, Mexico dropped its absolute ban on Asian rice imports in 1997. However, for practical reasons the ban continues since Asian rice exporters are obligated to show their rice is free of selected pests and produced in a region without a history of these pests (Trejo). Currently, no Asian rice exporting nation has met this qualification. However, some believe Thailand will eventually become eligible to reenter the Mexican market and displace or severely reduce the U.S.'s role in that market. Thailand traditionally competes with the United States in high-quality, long-grain rice markets with its 100 percent, Grade B long-grain rice: this rice is viewed as a close substitute for the U.S.'s No.2 long-grain, 4% broken product.

In view of the above issues, the objectives of this study are to (1) estimate the effect on U.S. rough, brown and white long-grain rice exports to Mexico that result from removal of Mexico's rice tariffs in 2003, and (2) estimate the effect on U.S. rough, brown and white long-grain rice exports to Mexico that would result from Mexico's acceptance of long-grain rice imports from Thailand.

Background

This section offers brief background regarding United States and Mexico rice production, consumption, milling and trade of long-grain rice. Figure 1 offers an overview of the U.S. rice marketing system and rice markets in 1997-1998. Approximately 96 percent of U.S. rice exports to Mexico are the long-grain product, thus the focus on this rice class (www.stat-usa.gov/tradex.nsf). (In this study, all references to "tons" should be interpreted as short tons or 2000 lb. tons)

Production

United States

In recent years, U.S. rice production has averaged near 9.0 million tons (rough rice basis): long-grain rice production comprises about 70 percent of U.S. production while the medium- and short-grain classes make up about 29 and 1 percent, respectively. Leading long-grain rice producing states are in the South. Over one-half of long-grain rice production is concentrated in Arkansas (52%): other major producers include Louisiana (19.6%), Texas (12%), Mississippi (11.0%), Missouri (5.0%) and California (0.4%). See Figure 2 for a map of U.S. rice production. Virtually all of the rice production in Mississippi, Missouri and Texas is of the long-grain class, whereas about 93 percent of production in Louisiana is a long-grain rice. In Arkansas, the leading rice producing state (44% of total U.S. rice production), long-grain production makes up about 82 percent of total production and, in California, the second-ranked rice producing state (21% of total U.S. rice production), long-grain production comprises about 1.0 percent of total output (USDA, *Crop Production 1998 Summary)*.

Mexico

Rice production in Mexico fluctuates widely: during the past two decades production has ranged from a low of 0.23 million tons in 1993 to 0.82 million tons in 1985. During the decade of the 1980s, rice production in Mexico averaged 0.57 million tons (rough rice basis), whereas production during the 1990s was about one-third lower at 0.38 million tons (www.econ.ag.gov/ProdSrvs/mostreq.htm). Mexico's rice production during the 1990s is generally characterized as downward trending. In part, the decline in production is a result of dramatic reductions in Sinaloa's rice production, Mexico's leading rice producing state until 1995. Inadequate water supplies and diversion of acreage to higher-valued horticultural crops has been central to reduced rice production in this state. Further, liberalization of Mexico's rice market in 1990 has led to comparatively low producer prices relative to substitute crops, and this in combination with increased input costs has brought about a decline in rice production (Hansen, Cramer, Wailes and Djunaidi).

During the mid-1990s, about one-third of Mexico's rice production was located in the state of Veracruz while Campeche and Sinaloa each comprised about 12 percent of Mexico's production. Other states with significant production shares were Michoacan (9%), Morelos (7%), Nayarit (7%) and Colima (4%) (Figure 3)(Salazar, Carlos, 1999*)*.

Mexico produces two types of rice: these are Sinaloa ("largo" or long) and Morelos ("grueso" or fat). Both are long-grain rices, but the kernel of the Morelos type is shorter and thicker than the Sinaloa type. Two varieties considered to be of the Morelos type are important: these are the "Morelos" and the "Milagro Filipino" varieties. Production of the Morelos variety is largely concentrated in the state of Morelos. The Milagro Filipino variety comprises the largest portion of Mexican rice production and is produced in all major producing states except Sinaloa, which produces almost exclusively the Sinaloa-type rice. The Sinaloa-type rice is similar to Mexico's long-grain imports from the United States. Mexico's production of the Sinaloa-type rice is concentrated in Sinaloa and Veracruz.

Consumption

United States

Consumption of rice (domestic disappearance) by the U.S. population has averaged about 5.2 million tons (rough rice basis) in recent years and nearly two-thirds (64%) of all U.S. rice consumption is of the long-grain class (USDA, *Rice Situation and Outlook Yearbook*). The U.S. has imported an average of 0.44 million tons of rice (rough rice basis) or about 8 percent of total U.S. consumption. Approximately 90 percent of U.S. rice imports are long-grain rice and based on the *U.S. Rice Distribution Patterns* publication most rice imports are destined for direct food use.

Mexico

Consumption of rice by the Mexican population is estimated to have averaged about 0.85 million tons (rough rice basis) in recent years with imports representing about half of total consumption (www.econ.ag.gov/ProdSrvs/mostreq.htm). Mexican millers indicate up to 70 percent of Mexico's rice consumption is comprised of the domestically-produced, Sinaloa-type rice and long-grain rice imports from the United States. Sinaloa-type rice is generally preferred to most of the Morelos-type rice according to Mexican millers, however, preferences tend to follow a geographic pattern. In particular, the Morelos-type rice is often preferred in the highland regions while Sinaloa-types are preferred in the northern and coastal regions. Per capita rice consumption in Mexico is about half that of the United States and the lowest in Latin America (USDA, *Rice Situation and Outlook Report*).

United States Exports and United States/Mexico Trade Flows

Exports of all U.S. rice in recent years have averaged about 4.2 million tons (rough rice basis) or 48 percent of production, whereas long-grain rice exports have averaged about 3.3 million tons and about 53 percent of U.S. long-grain rice production (USDA *Rice Situation and Outlook Yearbook*). On a rough rice basis, about 30 percent of U.S. long-grain exports were exported as white rice in 1995-1998: similar percentages were exported as rough and parboiled rice with the remaining 10 percent exported as brown rice (www.stat-usa/tradex.nsf).

Mexico imported an average of 0.412 million tons (rough rice basis) of U.S. long-grain rice during the 1995-1998 period or about 12.5 percent of U.S. long-grain rice exports. About 81 percent of U.S. long-grain exports to Mexico were exported as rough rice during 1994 -1998 while white, brown and parboiled rice comprised about 11, 4, and 4 percent, respectively, of these exports (rough rice basis). The portion of annual U.S. long-grain exports to Mexico as rough rice increased substantially after initiation of NAFTA in 1994. In 1994, about 54 percent of U.S. exports to Mexico were in the form of rough rice (rough rice basis), while in 1995, 1996, 1997, and 1998 about 71, 72, 88, and 92 percent of respective exports to Mexico were rough rice (www.stat-usa/tradex.nsf). Mexico's increase in rough rice imports is, in part, attributed to the comparatively low Mexican tariff on rough rice imports after initiation of NAFTA and the associated declines in this tariff *ex post* 1994.

From 1992 through 1997, virtually all of Mexico's imports of rough, brown and broken rice were from the United States while white rice imports came from a variety of countries until 1995. In 1992, the U.S. supplied about one-fourth of Mexico's white rice imports and Asian countries about 56 percent. Overall, the U.S. supplied about 46 percent of Mexico's rice imports in 1992. About one-third of Mexico's white rice imports were from the U.S. in 1993 and 1994 with remaining imports primarily from Asian countries, Argentina and Uruguay. Asian countries were important suppliers in 1993, however, in 1994 they were largely replaced by Argentina and Uruguay because of phytosanitary concerns regarding Asian rice. During 1993 and 1994, the U.S. supplied about three-fourths of Mexico's total rice imports. From 1995 through 1997, virtually all (99%) of Mexico's rice imports were from the United States (www.bancomext.com/esp/nest.c2.html). In 1998, Argentina signed a free trade agreement with Mexico that permits Argentina to make tariff-free white rice exports to Mexico (Osava). This development in combination with Thailand's potential reentry into the Mexican market may signal stronger competition for U.S. growers in this market.

The United States' proximity to the Mexican market and the potential transportation cost advantage may be important in retaining the Mexican market for U.S. producers. United States custom district data indicates most of the U.S.'s long-grain rice exports to Mexico move via overland routes: this flow pattern suggests the advantage of overland modes relative to marine transport for reaching many of Mexico's milling and consuming centers (dataweb.usitc.gov/scripts). Further, the railroad waybill data suggests most of the overland exports are transported via railroads.

Rough Rice

Nearly three-fourths of U.S. rough rice exports to Mexico during the 1995-1998 period were transported via overland routes: the Laredo customs district documented nearly 65 percent of U.S. rough rice exports to Mexico while the El Paso district handled about 10 percent of these exports. Less than one percent of the rough rice shipments exited the U.S. via Arizona and California crossings (dataweb.usitc.gov/scripts). The railroad waybill data for 1996 and 1997 suggests the majority of the overland shipments originate in Arkansas followed by Louisiana, Texas and Missouri. Shippers and railroad officials indicate virtually all of the overland shipments are transported in hopper cars which carry approximately 80 tons of rough rice.

Approximately one-fourth of the U.S.'s rough rice shipments to Mexico were documented by the New Orleans (24%) and Houston-Galveston (1%) customs districts in 1995-1998: based on conversations with rice handlers and exporters it is believed virtually all rough rice exports to Mexico via these two districts were transported by marine bulk carriers to east coast Mexican ports (dataweb.usitc.gov/scripts). Since most of these rough rice exports were documented by the New Orleans customs district, it suggests these rough rice exports to Mexico originated on the Mississippi, White and Arkansas Rivers (Arkansas, Louisiana, Mississippi) and were transported in bulk by barge to mid-stream elevators in the lower Mississippi River port area where the rice is loaded directly from barge to ocean-going bulk carrier.

White and Brown Rice

Customs district data show about 87 percent of U.S. long-grain white and brown rice exports to Mexico moved via overland transport modes in 1995-1998. On average, the Laredo customs district documented about 60 percent of the white and brown rice exports to Mexico. The San Diego district ranked second as a crossing location with white and brown rice export shares of 16 and 19 percent, respectively, while the respective shares handled by the El Paso district averaged 12 and 4 percent over the 1995-1998 period (dataweb.usitc.gov/scripts). Nearly all white rice exports to Mexico are in 50 kg sacks and most overland shipments are in boxcars that carry 70 tons/car. Although most overland shipments of white rice are transported by rail, conversations with selected millers indicate trucks are also used to transport small quantities of white rice into Mexico. Typically, brown rice is transported to Mexico in hopper cars that carry about 95 tons.

Approximately 13 percent of the U.S. long-grain white and brown rice exports to Mexico during 1995-1998 were documented by the Houston-Galveston and New Orleans customs districts (dataweb.usitc.gov/scripts). Shippers indicate exports via these districts typically move via marine transportation to Mexico. The Houston-Galveston district documented about 10 percent of the white rice exports to Mexico while New Orleans documented a similar share of brown rice shipments. White rice is sacked (50 kgs) and moved via liners while brown rice is transported in bulk carriers.

United States and Mexico Milling Industries

The relative efficiency of the United States and Mexico rice milling industries is expected to have an important influence on the future milling location (United States or Mexico) of U.S. rice exports to Mexico. Mexico's comparatively low tariff on U.S. rough rice imports since 1994 has favored the importation of U.S. rough rice, however, with removal of tariffs on all product forms in 2003, the relative efficiency of the U.S. and Mexico milling industries would seem to become increasingly critical in determining which country's milling industry processes U.S. exports and the associated product form of the U.S. exports.

United States

The U.S. rice milling industry tends to be located in those regions where rice is produced. Mills typically receive rice that has been dried at facilities near production locations. Approximately 44 rice mills are currently operated in the United States: Arkansas leads in rice mills with an estimated 13 plants followed by California and Texas which each have nine plants. Louisiana includes an estimated eight plants while Mississippi contains two plants. Florida, Missouri, and Tennessee each include one plant (Rice Journal). The milling industry tends to be geographically concentrated near Stuttgart, Arkansas; Crowley, Louisiana; Houston, Texas; and Sacramento, California.

Smith, Wailes and Cramer show the number of active mills in the U.S. to have changed significantly over time. Active rice mills in the U.S. declined from 65 plants in 1962 to 40 plants in 1972. Adoption of new milling technology during this period increased mill size and lowered plant cost, thus the contraction in plant numbers. However, by 1978, active rice mills had expanded to 44 and in 1985 an estimated 66 plants operated in the United States. However, by 1992, Setia, Childs, Wailes and Livezey show active mills had declined to 54. Currently, an estimated 44 rice mills operate in the United States, thus a continuing contraction in operating rice mills.

Mexico

According to the USA Rice Federation, 47 rice mills currently operate in Mexico. In general, rice mills tend to be located in production regions and in the State of Mexico and Federal District. For example, nine mills are located in the state of Veracruz and seven mills in Sinaloa, historically the two leading rice producing states in Mexico while the state of Mexico and District Federal includes six mills. Many of the Mexican mills are private mills that are owned by cooperatives of *ejidos* and are not viewed as commercially viable operations (Cramer, Young and Wailes). In 1993, Cramer, et al. estimated that Mexico included 23 major commercial rice mills. More recently, it is estimated that six mills may process up to 90 percent of commercial mill output in Mexico, thus greater concentration in the milling industry than implied by the comparatively large number of mills operating in that country.

In contrast to the United States, virtually all rice drying in Mexico is carried out at the milling sites, thus farmers are often required to assemble green rice extended distances. This factor, in addition to other unfavorable drying conditions, have created comparatively low milling yields for Mexican-produced rice. Mexican millers report 100 kgs of domestically-produced rough rice typically yields 22 kgs of hulls, 38 kgs of first heads, 32 kgs of brokens and 8 kgs of bran. In contrast, 100 kgs of imported rough rice yields 20 kgs of hulls, 55 kgs of first heads, 13 kgs of brokens and 12 kgs of bran. United States mills expect a total milled yield of at least 70 percent (70 kgs of milled output/100 kgs of rough rice) with 55 to 56 percent head rice, 14 to 15 percent brokens and 10 percent bran.

Model and Procedure

To accomplish research objectives a spatial, multiproduct equilibrium model that includes the United States and Mexico long-grain rice sectors was specified and estimated. The quadratic programming model generates regional milling output and interregional trade flows of rough, brown and white rice that result from maximizing producer plus consumer surplus minus rice milling, storage, handling and transportation costs (Samuelson; Takayama and Judge). The multiproduct model includes processing, transportation and handling charges unique to each rice product and its handling system.

Regional rough rice supplies and regional white and brown rice demands in the United States, and regional rough rice supplies and white rice demands in Mexico are included in the model. Regional supplies are represented at the farm-level and regional demands are represented at the packer-level of the rice marketing chain. Rough rice storage costs for Mexico and the United States are included in the annual model. In addition, the model features regional rice milling sites, ports, rail border-crossing sites for the United States and Mexico as well as barge-loading sites in the United States. Rough and brown rice are handled in bulk while white rice is handled in sacks and bulk. The U.S. supply regions are linked by rough rice transportation rates to U.S. mills, barge-loading sites, ports and border-crossing sites, while U.S. mill sites are linked to domestic demand regions, barge-loading sites, ports and border-crossing sites with brown and white rice transportation rates. The U.S. and Mexico mill sites include representative milling charges while all intermodal transfer facilities (barge-loading sites, ports) include handling charges for each rice product. All U.S./Mexico trade links incorporate Mexico's *ad valorem* tariff for each rice product, using the rates in effect during 1996 (6% on rough rice, 12% on brown and white rice). Representative rough rice storage costs for Mexico and the United States are included in the annual model. The U.S. ports are linked to Mexican ports by maritime ship rates for rough, brown and white rice and border-crossing sites are linked to Mexican milling sites and Mexican demand regions with the appropriate rice product transportation rates. Mexican supply regions are connected to Mexican mill sites with rough rice transport rates as are Mexican ports. Brown rice transportation rates link Mexican ports and mills. Mexican ports are also linked to Mexican demand regions with white rice transportation rates as are Mexican mills. In addition, the trade model includes rest-of-world demand faced by the United States for long-grain rough, brown and white rice and Thailand's excess supply of its high-quality, long-grain white rice.

The following is a mathematical representation of the U.S./Mexico rice trade model under the assumption of linear demand and supply relationships. Equation 1 is the non-linear objective function which is maximized subject to constraints 2 through 16. See Table 1 for definition of subscripts, parameters and variables included in the following equations:

(1) Maximize z

$$\{ -\sum_{i} (\alpha_{ir} + 0.5\, \beta_{ir} S_{ir}) S_{ir}$$

$$-\sum_{f} (\alpha_{fk} + 0.5\, \beta_{fk} S_{fk}) S_{fk}$$

$$-\sum_{a} (\alpha_{ar} + 0.5\, \beta_{ar} S_{ar}) S_{ar}$$

$$+ \sum_k (\sum_{j} (\alpha_{jk} - 0.5\, \beta_{jk} D_{jk}) D_{jk}$$

$$+ \sum_{d} (\alpha_{dk} - 0.5\, \beta_{dk} D_{dk}) D_{dk}$$

$$+ \sum_{h} (\alpha_{hk} - 0.5\, \beta_{hk}) D_{hk}) \}$$

$$- \{ \sum_{m} (\sum_{i} (\sum_{c} C_{icm} T_{icmr} + \sum_{b} C_{ibm} T_{ibmr} + \sum_{p} C_{ipm} T_{ipmr} + \sum_{e} C_{iem} T_{iemr}))$$

$$+ (\sum_{k} (\sum_{c} (\sum_j C_{cjm} T_{cjmk} + \sum_{b} C_{cbmk} T_{cbmk}$$

$$+ \sum_{p} C_{cpm} T_{cpmk} + \sum_{e} C_{cem} T_{cemk})$$

$$+ \sum_{b} \sum_{p} C_{bpm} T_{bpmk} + \sum_p (\sum_d C_{pdm} T_{pdmk}$$

$$+ \sum_{g} C_{pgm} T_{pgmk}) + \sum_{l} \sum_{g} C_{glm} T_{glmk}$$

$$+ \sum_{e} (\sum_{l} C_{elm} T_{elmk} + \sum_{h} C_{ehm} T_{ehmk})$$

$$+ \sum_{h} (\sum_{g} C_{ghm} T_{ghmk} + \sum_{l} C_{lhmk}) T_{lnk}) + \sum_a \sum_{l} C_{alm} T_{almr}$$

$$+ \sum_{f} \Big(\sum_{d} C_{fdm} T_{fdmk} + \sum_{g} C_{fgm} T_{fgmk} \Big) \}$$

$$- \sum_{k} \sum_{n} \Big(\sum_{c} C_{cnk} T_{cnk} - \sum_{l} C_{lnk} T_{pnk} \Big)$$

Subject to

(2) $$\sum_{m} \Big(\sum_{c} T_{icmr} + \sum_{b} T_{ibmr} + \sum_{p} T_{ipmr} + \sum_{e} T_{iemr} \Big) \leq S_{ir} \text{ for all } i\,;$$

(3) $$\sum_{m} \Big(\sum_{d} T_{fdmk} + \sum_{g} T_{fgmk} \Big) \leq S_{fk} \text{ for all } f \text{ and } k\,;$$

(4) $$\sum_{m} \sum_{l} T_{almr} \leq S_{qr} \text{ for all } a\,;$$

(5) $$\sum_{rm} \Big(\sum_{j} V_{k} T_{cjmk} + \sum_{e} V_{k} T_{cemk} + \sum_{p} V_{k} T_{cpmk} + \sum_{b} V_{k} T_{cbmk} \Big) \leq \sum_{m} \sum_{i} T_{icm} \text{ for all } c,\ k\,;$$

(6) $$V_{nk} T_{cnk} \leq \sum_{m} \Big(\sum_{j} T_{cjmk} + \sum_{e} T_{cemk} + \sum_{p} T_{cpmk} + \sum_{b} T_{cmbk} \Big) \text{ for all } c,\ n,\ k\,;$$

(7) $$\sum_{m} \sum_{p} T_{bpmk} \leq \sum_{m} \Big(\sum_{c} T_{cbmk} + \sum_{i} T_{ibmr} \Big) \text{ for all } b,\ k\,;$$

(8) $$\sum_{m} \Big(\sum_{d} T_{pdmk} + \sum_{g} T_{pgmk} \Big) \leq \sum_{m} \Big(\sum_{c} T_{cpmk} + \sum_{b} T_{bpmk} + \sum_{i} T_{ipmr} \Big) \text{ for all } k,\ p\,;$$

(9) $$\sum_{m} \Big(\sum_{l} T_{elmk} + \sum_{h} T_{ehmk} \Big) \leq \sum_{m} \Big(\sum_{c} T_{cemk} + \sum_{i} T_{iemk} \Big) \text{ for all } e,\ k;$$

$$\textbf{(10)} \quad \sum_m \left(\sum_l T_{glmk} + \sum_h T_{ghmk} \right) \le \sum_m \left(\sum_p T_{pgmk} + \sum_f T_{fgmk} \right) \text{ for all } g, k;$$

$$\textbf{(11)} \quad \sum_m \sum_h V_k T_{lhmk} \le \sum_m \left(\sum_a T_{almk} + \sum_g T_{glmk} + \sum_e T_{elmk} \right) \text{ for all } l, k;$$

$$\textbf{(12)} \quad V_{nk} T_{lnk} \le \sum_m \sum_h T_{lhmk} \text{ for all } l, n, k;$$

$$\textbf{(13)} \quad \sum_m \left(\sum_g T_{ghmk} + \sum_e T_{ehmk} + \sum_l T_{lhmk} \right) \ge D_{hk} \text{ for all } h, k,;$$

$$\textbf{(14)} \quad \sum_m \sum_c T_{cjmk} \ge D_{jk} \text{ for all } j, k;$$

$$\textbf{(15)} \quad \sum_m \left(\sum_p T_{pdmk} + \sum_f T_{fdmk} \right) \ge D_{dk} \text{ for all } d, k;$$

$$\textbf{(16)} \quad T, S, D \ge 0 \text{ for all } a, b, c, d, e, f, g, h, i, j, k, l, m, n, p, r.$$

The objective function (1) maximizes net social payoff or consumer plus producer surplus minus milling, handling, storage, and transportation costs. Excess supply functions in the model represent rough rice with the exception of Thailand's excess supply of white rice. Excess demand functions represent all rice product forms (rough, brown, and white). The rest-of-world demands faced by the United States represent rough, brown and white rice products. Mexico includes white rice demands at the packer-level of the market channel, and the United States includes white and brown rice demands at the packer-level. Equation 2 constrains quantity of rough rice shipments from each U.S. supply region to all U.S. mills and transhipment locations (barge-loading sites, ports, and border locations) by all transport modes to be less than or equal to the quantity supplied by each region. Equation 3 constrains quantity of white rice shipped from Thailand to its final foreign destination and transhipment points at Mexican ports to be less than or equal to its quantity supplied. Equation 4 constrains the quantity of rough rice shipped from each Mexico supply region to all Mexican mills by all modes to be less than or equal to the quantity supplied by each region. Equation 5 limits the quantity of milled rice shipped from each U.S. mill to U.S. demand regions, barge-loading sites, ports, and border-crossing locations by all modes to be less than or equal to each mill's rough rice receipts multiplied by the milling technical coefficients. Equation 6 constrains the quantity of by-products shipped from each U.S. mill by all transport modes to U.S. by-product demand and transhipment locations to be less than or equal to mill by-product output as determined by the mill's rough rice receipts and the milling technical coefficients. Equation 7 constrains all forms of rice product shipments from each barge-loading site to be less than or equal to receipts of each rice product from U.S. mills and supply locations. Equation 8 constrains the quantity shipped of each rice product by all appropriate modes from each U.S. port to the rest-of-the-world demands and Mexican ports to be less than or equal to port receipts of each rice product from U.S. mills, supply locations, and barge-loading sites. Equation 9 constrains rice shipments from each U.S./Mexico border-crossing site to Mexico locations to be less than or equal to rice received at the border site from U.S. mills and supply locations. In particular, shipments of each rice product from each U.S./Mexico border-crossing site by applicable transport mode to Mexican mills and Mexican demands must be less than or equal to each border-crossing's receipts of each rice product from U.S. mills and supply locations. Equation 10 constrains quantity of each rice product shipped from each Mexican port to Mexican mills and demand locations by all applicable transport modes to be less than or equal to Mexican port receipts of each rice product by applicable mode from U.S. and Thailand ports. Equation 11 constrains shipments of each rice product from each Mexican mill to Mexico demand locations by all modes to be less than or equal to the sum of rough rice receipts from Mexico supply locations, ports, and border-crossing locations after application of the milling technical coefficients. Equation 12 constrains the quantity of by-products shipped from each Mexican mill by all applicable transport modes to Mexican demands to be less than or equal to mill by-product output which is determined by the mill's rough rice receipts and its milling technical coefficient. Equation 13 forces quantity of white rice receipts at each Mexican demand region by all applicable transport modes from all Mexican mills, ports, and border-crossing sites to be greater than or equal to the quantity demanded by the Mexican region. Equation 14 forces quantity of white rice and brown rice receipts from all transport modes in each U.S. white and brown rice demand region to be greater than or equal to quantity demanded of each rice product. Equation 15 forces shipments of rice products from U.S. ports to rest-of-world demand locations to be greater or equal to the quantity demanded at these locations. Equation 16 includes the non-negativity conditions.

The U.S. portion of the rice trade model includes 17 rough rice supply regions, nine white and brown rice demand regions, eight rice milling sites, four port areas, eight barge-loading sites and six border-crossing locations (Tables 2 and 3). Six supply regions are included in Arkansas. Louisiana is represented by four supply regions while Texas, Mississippi, Missouri, and California have three, two, one, and one supply regions, respectively. Representative rice milling sites are located at New Madrid, Missouri; Jonesboro, Arkansas; Stuttgart, Arkansas; Greenville, Mississippi; Crowley, Louisiana; Beaumont, Texas; Houston, Texas and Sacramento, California. Ports in the U.S. portion of the model are located at New Orleans, Louisiana; Lake Charles, Louisiana; Houston, Texas and San Francisco, California. Border crossing locations at Brownsville, Texas; Laredo, Texas; Eagle Pass, Texas; El Paso, Texas; Nogales, Arizona and Calexico, California are included in the trade model (Figure 3). Seven barge loading sites are situated on the Mississippi and Arkansas Rivers and one barge-loading site is included on the Louisiana portion of the Gulf Intracoastal Waterway.

The Mexico portion of the trade model includes nine rough rice supply regions, nine white rice demand regions, twelve rice milling sites, two port areas and six border-crossing locations (Table 4). Regional supplies of rice are represented by states. They include Campeche, Colima, Jalisco, Michoacan, Morelos, Nayarit, Sinaloa, Tabasco and Veracruz. Mexico rice milling sites are at Champoton, Campeche; Cardenas, Tabasco; Cordoba, Veracruz; Ixtla, Morelos; Pantaco, Mexico; Zamora, Michoacan; Guadalajara, Jalisco; Ixltan, Nayarit; Ciudad Mante, Tamaulipas; Monterrey, Nuevo Leon; Celeya, Guanajuato; and Culiacan, Sinaloa. The Mexico border crossing sites are identical to those included in the U.S. portion of the model. Mexican ports are represented in the model by Veracruz, Veracruz and Manzanillo, Colima.

The spatial, multi-product model includes U.S. and Mexico rice production, consumption, transportation and logistics charges, and Mexican tariffs that are representative of the latter 1990s. The solution of this model will serve as a base or reference point in the analysis. To validate the base model, the base model solution will be contrasted with actual flow patterns and prices that existed in the latter 1990s. Following successful model validation, the developed model will be used to accomplish study objectives. To evaluate the influence of zero Mexican rice tariffs in 2003, tariff levels reflective of the latter 1990s will be lowered to zero in the base model and the model solved. Then, the solution to this modified model will be contrasted with the base model solution to isolate the influence of the zero Mexican tariff. To evaluate the effect of removing Mexico's ban on imported Thailand rice, constraints in the base model which prohibit imports of Thailand rice will be removed and the model solved. By contrasting the base model solution with that solution which is absent the constraint on imports of Thailand rice, the effects of Mexico's ban removal will be revealed.

Model Data

The multi-product, spatial model of U.S./Mexico long-grain rice trade was constructed with regional estimates of United States and Mexico white rice demand and rough rice supply equations; equations representing rest-of-world rough, brown and white rice demands faced by the United States; equations representing Thailand's excess white rice supply and rest-of-world white rice demand; rice processing, storage and handling charges; and applicable railroad, truck, barge and ship rates for rough, brown and white rice. The developed model is representative of the latter 1990s, accordingly, parameters were selected that represent this period.

Supplies

Regional long-grain rough rice supply equations for the United States and Mexico were obtained with historic information on regional rice production, supply elasticities, historical farm-level prices, and data on seeding rate, historical yield and portion of state production that was long-grain rice. Crop reporting districts served as supply regions. The obtained supply equations were net or excess supplies that accounted for planting seed. The supply elasticity in combination with excess long-grain rice supplies and price facilitated estimation of slope and intercept for an inverse excess supply equation.

Historic rice production and yield by U.S. crop reporting district were obtained for 1994-1997 as was the portion of state production that was long-grain rice (usda2.mannlib.cornell.edu/data-sets/crops). Total rice production in each supply region was adjusted by the historic portion of state-level rice production which was long-grain. Representative rice seeding rates for each state were obtained from Extension agronomists in rice producing states. Farm-level prices came from the National Agricultural Statistical Service (www.usda.gov/nass) and supply elasticities were from an unpublished paper by Penson and Grant titled, "Survey Literature on Rice Elasticities." Estimated supply elasticities for production regions in Arkansas, California, Louisiana, Mississippi, Missouri and Texas were 0.112, 0.191, 0.061, 0.175, 0.112, and 0.085, respectively. The developed model includes 6.25 million tons of U.S. long-grain, rough rice supply. The six supply regions in Arkansas include 52 percent of U.S. long-grain rice production while supply regions in Louisiana, Texas, Mississippi, Missouri and California represent 19.6, 12.0, 11.0, 5.0 and 0.4 percent, respectively, of total supply.

The procedure to estimate rice supply equations in Mexico was similar to that followed in the United States. However, in Mexico, data limitations necessitated that states serve as supply regions. Production of rice by state was obtained from Secretaria de Agricultura, Ganaderia y Desarrollo Rural (SAGAR) as was rice yield (www.sagar.gob.mx/sagar.htm). Historic farm-level rice prices were from SAGAR, Centro de Estadistica Agropecuaria. Mexico's rice supply elasticity (0.65) was taken from the USDA publication, *A Database for Trade Liberalization Studies.* The developed model includes 0.449 million tons of rough rice production: approximately 30 percent of this production (0.129 million tons) was estimated to be long-grain rice. Long-grain rice production by state was estimated from interviews with selected Mexican rice millers and SAGAR personnel in rice-producing states. Approximately 38 percent of Mexico's total rice production was in the state of Veracruz and nearby states, while remaining production was in Sinaloa (15%), Campeche (12%), Michoacan (10%), Morelos (7%), Nayarit (7%), Colima (4%), Tabasco (4%) and Jalisco (3%). The estimated share of Mexico's long-grain rice production by state was as follows: Sinaloa (52%), Veracruz (39%), Campeche (4%), Colima (3%), Jalisco (1%) and Tabasco (1%).

Demands

Regional long-grain white and brown rice demand equations in the United States and white rice demands in Mexico were based on estimates of regional consumption, demand elasticities, and prices at the packer level of the market channel. The demand elasticity, in combination with the regional estimate of rice consumption and price, facilitated estimation of slope and intercept for an inverse demand equation. In the United States and Mexico, regional demands were represented by selected contiguous states.

United States long-grain rice consumption (disappearance) of U.S.-produced rice was included in the model at 2.9 million tons (rough rice basis): this estimate was from the USDA's *Rice Situation and Outlook Yearbook* and was viewed as representative of the latter 1990s. Additional U.S. demand information came from annual reports of the USA Rice Federation titled *U.S. Rice Distribution Patterns*: annual reports for 1994-95 through 1997-98 provided information on consumption. White and brown rice demands in the United States were estimated to be 2.0 and 0.03 million tons, respectively. An estimated 1.57 million tons of the white rice demand was associated with direct food use while remaining consumption (0.43 million tons) was for processing and beer. Model demand regions are those defined in the *U.S. Rice Distribution Patterns* publication: this publication's historical shipments of milled rice for direct food use served as a guide for allocating direct food use demand (1.57 million tons) among the nine U.S. regions. Remaining white rice demand (0.43 million tons) was assigned to the nine regions based on population. The nine demand regions and their share of long-grain rice consumption as direct food are: Pacific (24%), Mountain (2%), West North Central (4%), West South Central (11%), East North Central (8%), East South

Central (6%), South Atlantic (19%), Middle Atlantic (21%) and New England (5%) regions (Table 3). The U.S. own-price demand elasticity came from Penson and Grant and was estimated to be -0.18. Regional prices were estimated from F.O.B. mill price information in *Rice Situation and Outlook Yearbook* and transportation costs to the identified demand regions.

The procedure to estimate regional white rice demand equations for Mexico was similar to that followed for the United States. Estimates regarding regional white rice consumption were based on a national survey by Instituto Nacional de Estadistica, Geografia e Informatica (INEGI) which offered insight on rice consumption habits by state and USDA data (www.econ.ag.gov/ProdSrvs/mostreq.htm). National white rice consumption was estimated at 0.60 million tons: based on state population information from INEGI (www.inegi.gob.mx) and SAGAR, estimates of per capita consumption (Sistema Production de Arroz Palay) and, state and regional white rice consumption estimates were obtained. Mexico's white rice demand was included in nine regions: the regions and the associated share of consumption are as follows: Northwest (10%), North (6%), Northeast (6%), North Central (11%), West (11%), Central (29%), Gulf (11%), South Pacific (12%), and Yucatan (4%) regions. Based on a survey of Mexican rice millers and packers it was estimated that two-thirds (0.40 million tons) of Mexico's white rice consumption was the Sinaloa-type rice and long-grain rice imports from the United States. The nine consumption regions and their associated share of long-grain consumption are as follows: Northwest (12%), North (7%), Northeast (7%), North Central (5%), West (11%), Central (25%), Gulf (14%), South Pacific (14%) ,and Yucatan (5%) (Table 4). Regional prices in Mexico were approximated with U.S. port/border prices and transportation costs to the region. Mexico's rice demand elasticity was estimated to be -0.30 (Duloy and Norton). This estimate was similar to that by Fernandez (-0.21) and that in *The Database for Trade Liberalization Studies* (-0.40).

Milling Charges

Estimates of representative milling charges by U.S. mills for export-destined brown and white rice were obtained from mills in Arkansas, Louisiana, and Texas. Although quoted milling charges were somewhat higher in Louisiana and Texas than Arkansas, the number of observations were too small to differentiate milling charges by state. Thus, one milling charge was estimated. The estimated charge for milling rough into white rice was $31/ton of rough rice with the miller receiving the associated hull and bran. Hulls were assumed to have almost no value while one ton of rough rice was estimated to yield about $6.80 of bran. Since the U.S. may export additional quantities of brown rice to Mexico *ex post* tariff removal in 2003, it was necessary to include associated milling charges: millers suggested $18 to 20/ton was a representative charge for milling rough into brown rice.

Interviews with Mexican millers suggested a milling charge of $28.95/ton of rough rice would be representative for milling rough into white rice with the miller receiving all by-products. Rice bran by-product values were estimated to be $16/ton of milled rice. Because Mexico may import additional quantities of brown rice *ex post* tariff removal, it was necessary to estimate representative charges for milling brown into white rice. Based on a conversation with a U.S. miller who was familiar with Mexico's milling processes, the charge to mill brown into white rice was estimated to be $19.40/ton.

Transportation--United States

Numerous rail, truck, barge and ship transportation links are included in the model for rough, brown and white rice. Industry transportation personnel indicated rough and brown rice are transported in bulk while white rice may be transported either in bulk or sacks. The developed model represents prevalent handling systems for export-destined rice products. At the New Orleans port (lower Mississippi River) all rice products are handled in bulk: virtually all exports from lower Mississippi River facilities are received by barge from origins on the Mississippi, Arkansas and White Rivers. Rough and brown rice are handled in bulk at the Lake Charles and Houston ports while their white rice handling systems accommodate bulk and sack. Nearly all receipts at the Lake Charles and Houston ports arrive via motor carrier and rail modes. Overland white rice (railroad) exports to Mexico are assumed to be in 50 kg sacks (boxcars) while rough and brown rice movements are in bulk (hopper cars).

Railroads

Rough, brown and white rice rail rates for the United States were provided by the Union Pacific Southern Pacific Railroad. Rough rice rail rates link U.S. supply regions to ports and U.S./Mexico border-crossing locations in the trade model. Typically rough rice is transported in hopper cars which carry approximately 80 tons, accordingly, all per ton rail charges were calculated with this parameter. Rough rice rates linking Arkansas supply regions to the Brownsville, Laredo and Eagle Pass, Texas border-crossing sites range from $19.25 to $23.00/ton while rates to the El Paso, Texas crossing range from $24.40 to $25.64/ton. Rates from Louisiana supplies to Brownsville, Laredo and Eagle Pass range from $20.20 to $22.40/ton, whereas rates to El Paso range from $24.40 to $26.60/ton. Rates from Texas supply regions to Brownsville, Laredo and Eagle Pass range from $14.75 to $15.25/ton while rates to El Paso range from $23.60 to $24.40/ton. Missouri and California supply regions are also linked to border locations: Mississippi supplies were not linked to ports or border-crossing sites because serving railroads indicated they transport small quantities of rice. Rough rice rail rates to Gulf ports from supply regions in Arkansas, Louisiana, and Texas average $16, $12, and $11/ton, respectively.

Brown rice rail rates link the trade model's U.S. milling sites to Gulf ports, border-crossing sites and domestic demand regions. Brown rice is transported in hopper cars which carry about 95 tons. Rates from Arkansas, Louisiana, and Texas mill sites to border-crossing locations at Brownsville, Laredo, and Eagle Pass average $27, $22, and $16/ton, respectively, while respective rates to El Paso are about 15 percent greater. Estimated brown rice rates from mill sites in Arkansas, Louisiana, and Texas to Gulf ports average $20, $16, and $13/ton, respectively.

White rice rail rates connect the trade model's U.S. milling locations to Gulf ports, border-crossing sites and nine domestic demand regions. Shippers indicate most of the U.S.'s exports of white rice to Mexico are in 50 kg sacks which are transported via boxcars (70 tons/car), thus all overland white rice railroad rates in the model reflect boxcar movements. Rail rates from milling sites in Arkansas, Louisiana, and Texas to ports average about $17, $15, and $15/ton, respectively. Rates on shipments of white rice from Arkansas mills to the Brownsville, Laredo, and Eagle Pass border-crossing sites average $35/ton while rates to crossing locations in Arizona and California range up to $50/ton. White rice rail rates from Louisiana mills to the Brownsville, Laredo, and Eagle Pass sites average about $28/ton while rates from Texas mills to these border-crossing sites average about $23/ton. Rates from Texas and Louisiana mills to Arizona and California crossing sites range from $42 to $44/ton.

White rice railroad rates link U.S. mill sites to the nine U.S. domestic demand regions. Rates from Arkansas milling sites to the nine demand regions range from $22/ton to near $50/ton. The lowest rates are to the west south central (Dallas, Texas) and east south central (Nashville, Tennessee) regions where respective rates are $22 and $23/ton: highest rates are to the New England region (Boston, Massachusetts) ($47/ton) and the Pacific region (Sacramento, California) ($49/ton). Rates from Texas mills to domestic demand regions range from $19/ton (west south central region) to $53/ton (middle Atlantic region) while rates from Louisiana mills to domestic demand centers range from $22/ton (west south central region) to $51/ton (New England region).

Motor Carriers

Motor carrier rate information for rough, brown and white rice movements was supplied by shippers and trucking companies. Motor carrier rates for bulk shipments of rough, brown and white rice were found to be virtually identical, thus the same rate structure was used to calculate these trucking rates. Rough rice rates link U.S. supply regions to barge-loading sites, milling sites and ports: brown rice rates connect mills to barge-loading sites and ports, and rates associated with bulk shipments of white rice link mills with barge-loading sites. Motor carrier rates tend to be lowest in Arkansas and highest in Texas. For example, at distances of 50, 100, and 150 miles, the respective rates in Arkansas are estimated to be $4.76, $7.73, and $10.68/ton while rates for the corresponding distances in Texas are estimated to be $5.60, $9.00, and $11.60/ton, respectively. In the trade model, motor carrier rates link supply regions in east Arkansas, southeast Missouri, northwest Mississippi, and northeast Louisiana to barge-loading sites on the Mississippi and Arkansas Rivers: these rates range from $3.60 to $8.00/ton. In addition, rough rice motor carrier rates link southwest Louisiana supply regions to a barge-loading site on the Gulf Intracoastal Waterway with a similar rate structure. Estimated rates on motor carrier shipments of rough rice from supply regions to mill sites average about $6.80/ton while shipments to port areas range from $7.80 (Texas origins) to $42/ton (Missouri origin). The average truck rate shipments of rough rice from Arkansas supply regions to port is $27/ton.

Brown rice motor carrier rates link the model's U.S. mill sites to barge-loading locations and ports. For mill sites in Arkansas, Missouri, Mississippi, and northeast Louisiana, the rate to barge-loading sites range from $2.00/ton (Missouri and Mississippi) to about $6.00/ton (Arkansas), whereas rates from southwest Louisiana mills to a barge-loading site on the Gulf Intracoastal Waterway average $5.60/ton. In the trade model, rates from mill sites to port areas range from about $5/ton (Texas mill) to $40.00/ton (Missouri mill).

The trade model's U.S. mill sites are linked to barge-loading locations and ports via white rice motor carrier rates. Mill sites in Arkansas, Missouri, Mississippi, and northeast Louisiana may ship white rice in bulk to barge-loading sites on the Mississippi and Arkansas Rivers while southwest Louisiana mills can ship to a barge-loading site on the Gulf Intracoastal Waterway. Shippers and truckers indicated bulk shipments of white rice move at the same rates as bulk shipments of rough and brown rice, thus motor carrier rates for mill shipments of white rice in bulk are identical to those for brown rice. In contrast, sacked white rice shipments from mills to port areas were about $1/ton higher than bulk shipments: the higher cost was attributed to the additional labor associated with tarp handling.

Barges

The Mississippi and Arkansas Rivers serve as important transportation arteries for rice production areas in Arkansas, Mississippi, Missouri and northeast Louisiana. Barges transport substantial quantities of rough, brown and white rice in bulk from these states to five mid-stream export operations in the lower Mississippi River port area. These facilities transfer rice directly from barge to ocean-going vessel: these facilities have no ability to store or receive from other transport modes. In the model, barge-loading sites are at New Madrid, Missouri; Osceola, Arkansas; Memphis, Tennessee; Helena, Arkansas; Dumas, Arkansas; Pine Bluff, Arkansas; and Greenville, Mississippi. The respective rates from these sites to the lower Mississippi River port area were estimated to be $7.20, $6.65, $6.00, $5.75, $5.00, $5.95, and $4.50/ton. An additional barge-loading site is included at Mermentau, Louisiana (Gulf Intracoastal Waterway): this site is linked to lower Mississippi River ports and a port/mill facility in Houston, Texas.

Ship

In the trade model, ship rates link U.S. Gulf ports (New Orleans, Lake Charles, Houston) to the Mexican port at Veracruz. Ship rate information was obtained from U.S. customs brokers and Mexican importers. Rates on rough and brown rice shipments in bulk were found to average about $19/ton: this rate is based on free-in-and-out terms (FIO). Under FIO terms, the ship charterer is responsible for loading and unloading of cargo. The corresponding rate on sacked rice shipments is estimated to be $24/ton (FIO).

Intermodal Transfer and Other Charges

Intermodal transfer charges at barge-loading sites and ports are included in the trade model as are rice grading and rough rice storage charges. This information was obtained from shippers, port operators, exporters/importers, rice driers, and customs agents. The representative charge for transferring rough, brown and white rice in bulk from truck to barge on the Mississippi/Arkansas Rivers is estimated at $2.40/ton, while the representative charge for transferring any rice product in bulk from a barge to an ocean-going vessel by a mid-stream operator on the lower Mississippi River (New Orleans) is estimated at $2.30/ton. In contrast, at the Lake Charles and Houston ports, the estimated charges for transferring rough or brown rice in bulk from a truck or railcar to an ocean-going vessel ranged from $4.50 to $7.00/ton. The estimated charges for transferring sacks of white rice from a truck or boxcar to an ocean-going vessel ranged from $16.20 to $18.60/ton at the ports of Lake Charles and Houston. The estimated charges for grading rough, brown or white rice in bulk was $1.00/ton, whereas the estimated charge for grading white rice in sacks is $2.00/ton. Managers of rice driers indicated rough rice storage charges averaged approximately $1.80/ton/month in the major rice producing areas.

Transportation--Mexico

Rail, truck, and ship transportation links are included in the Mexican portion of the trade model for rough, brown and white rice. The developed model represents prevalent rice handling systems and modes on various routes. In the model, all overland rail imports of white rice are in sacks (boxcars) while rough and brown rice are transported in bulk (hopper cars). Imports of white rice at the port of Veracruz may be either in bulk or sack while imports of rough and brown rice are in bulk. Mexican truckers are assumed to be the principal transporter of port receipts and intra-country rice movements.

Railroads

Rough, brown and white rice rail rates for Mexico were provided by Transportacion Ferroviaria Mexicana (TFM), operator of Mexico's northeast rail corridor. When rates were required for particular routes over which the TFM did not operate, rates were estimated with a regression model that was based on TFM rates and their associated distances. In the trade model, rough rice rail rates link U.S./Mexico border crossing sites to Mexican mill locations. At the border, the hopper cars are switched from a U.S. carrier to a Mexican carrier: the estimated per ton charge of transporting rough rice in Mexico was based on carriage of 80 tons. Rough rice rail rates from Laredo, the principal border crossing site, to Mexican mills in the states of Veracruz, Mexico, Jalisco, Nuevo Leon, Guanajuato, and Sinaloa average about $30.00, $24.80, $26.60, $9.10, $21.20, and $37.50/ton, respectively. Rates from Brownsville and the Eagle Pass crossing sites to the above identified states are similar to those via Laredo, however, rates from El Paso and other western crossing sites are generally higher. In general, rates from Laredo and other eastern crossing sites to the above identified milling sites are substantially below rates via the western crossing locations except for milling sites in northwest Mexico. For example, in Sinaloa the estimated rates via El Paso and Nogales are $24.45 and $20.25/ton, respectively, whereas via Laredo the rate is $37.50/ton.

Brown rice railroad rates link U.S./Mexico border-crossing sites to Mexican mill locations in the trade model. Rates are based on carriage of 95 tons per hopper car. Brown rice rates via east border crossing sites (Brownsville, Laredo, Eagle Pass) to Mexican milling centers in the states of Veracruz, Mexico, Jalisco, Nuevo Leon, Guanajuato, and Sinaloa average approximately $23.40, $19.50, $20.75, $7.25, $16.60, and $29.20/ton, respectively. Rates via east border crossing locations to milling sites in the above states are lower than via the western crossing sites except for milling destinations in Sinaloa where the estimated rate is $19.10/ton.

In the trade model, sacked white rice rail rates connect U.S./Mexico border-crossing sites to Mexican demand regions. The estimated per ton rates are based on carriage of 70 net tons of sacked white rice per boxcar. Rates via the Brownsville, Laredo and Eagle Pass crossing locations to

Mexico's northwest, north, northeast, north central, west, central, Gulf, south Pacific, and Yucatan demand regions are approximately $39.60, $16.70, $9.85, $24.60, $28.20, $26.40, $31.75, $35.90, and $54.60/ton, respectively. (Table 4) Except for Mexico's northwest demand region, rates via east border-crossing sites are lowest. The estimated rate to Mexico's northwest demand region via El Paso and Nogales crossing sites are $26.15 and $21.80/ton, respectively. In contrast, rates to the northwest demand region via the east crossing locations average nearly $40.00/ton.

Motor Carriers

Motor carriers in Mexico play an important role in rice transportation. Motor carriers assemble green rice from producers to milling sites where the rice is dried and milled: this is in contrast to the U.S. where drying is carried out on the farm or at a nearby drier site. Motor carriers link the port of Veracruz to Mexican milling sites with rough and brown rice rates. In addition, motor carriers link the port of Veracruz/Manzanillo to Mexican demand regions with bulk and sacked white rice rates. And, motor carrier rates for sacked white rice link Mexican mills to Mexican demand locations.

Information on charges associated with assembling green rice from farms to driers/mills was obtained from a Mexican rice producer. Estimated average assembly distances in Mexico's rice producing states range from 20 to 200 miles with an average assembly distance of about 95 miles. Estimated charges for hauls of 20, 50, 100, 150, and 200 miles are $4.30, $6.80, $10.90, $15.00, and $19.10/ton, respectively (rough rice basis).

Motor carrier rates associated with transporting rough and brown rice from ports to Mexican milling centers were obtained from Mexican millers. In the trade model, the estimated distances from port to Mexican milling locations range from 65 to 1100 miles. The rate for hauls of 100, 200, 300, and 400 miles were estimated at $10.30, $14.15, $17.95, and $21.70/ton, respectively. For example, the estimated rate for transporting rough/brown rice from the port of Veracruz to mill locations at Cordoba, Veracruz, and Pantaco, Mexico are $9.00 and $16.80/ton, respectively.

In the trade model, truck rates for sacked white rice link Mexican ports and milling centers to Mexican demand regions. Mexican rice millers provided information on sacked white rice truck rates. The estimated rates associated with transporting sacked rice 100, 200, 300, and 400 miles are $12.00, $19.55, $23.50, and $27.00/ton, respectively. Truck rates associated with transporting white rice in bulk were assumed analogous to rough rice rates: in the United States, truckers indicated that rates for bulk movements of rough and white rice were similar, thus the source of the assumption.

Ship

The maritime linkages between the United States and Mexican ports are described above in the U.S. section. In addition to import linkages with the United States, the trade model includes ship rates for sacked white rice that link the port at Bangkok, Thailand with the Mexican ports at Manzanillo and Veracruz. One of the estimated ship rates was obtained from implicit ship rate information in the National Trade Database, Bureau of Census and a U.S. miller involved in international shipping.

The estimated ship rate from Bangkok, Thailand to Manzanillo, Mexico was $64/ton (FIO) while the rate to Veracruz was estimated at $69/ton (FIO). Other sources estimated that ship rates linking Bangkok to Manzanillo may at times be as low as $44-$46/ton. For this reason, a range of ship rates are included into this analysis.

Intermodal Transfer and Other Charges

Estimated stevedoring and wharfage charges for imports of rough, brown and white rice in bulk at the port of Veracruz were supplied by Mexican rice millers. The estimated charge for these services is $3.35/ton. In addition, the model includes charges associated with imports of white rice in sacks. The estimated charges for these services is $10.43/ton. Mexican millers indicated customs agents charge about 0.25 percent of the value of the rice import. Information on rough rice storage charges in Mexico were also obtained from Mexican millers. The estimated charge for storing rough rice at Mexican mill sites is $1.76/ton: rough rice is assumed to be stored an average of three months in Mexico, according to a Mexican researcher.

United States' Rest-of-World Export Demand

Rest-of-the-world long-grain rice export demands faced by the United States were obtained with estimates of historic exports by rice product, prices for each product, and an excess demand elasticity. United States exports of long-grain rough, brown and white rice and their associated value were obtained for 1994-1998 from the National Trade Database (www.stat-usa.gov/tradex.nsf). Based on these data, implicit prices were obtained for each rice product form. Representative long-grain rice exports of rough, brown and white rice were estimated at 0.63, 0.26 and 1.37 million tons, respectively. The export demand elasticity was estimated to be -1.75 following the method forwarded by Bredahl, Meyers and Collins.

Thailand's Excess Supply and Rest-of-World Excess Demand

Thailand's 100 percent, Grade B long-grain rice was judged to be a close substitute for the U.S.'s No. 2, 4 percent broken long-grain rice in the Mexican market by Mexican millers and USDA personnel. Accordingly, an excess supply and demand were estimated for Thailand's exports of this rice. The excess supply relationship was obtained with an estimate of Thailand's excess supply elasticity for 100 percent, grade B long-grain rice; a representative F.O.B. Bangkok price for this quality of rice as well as a historically representative export level. The formula to estimate excess supply elasticity was that originally forwarded by Yntema: the formula is now common in the literature (Shei and Thompson). To estimate Thailand's excess supply elasticity it was necessary to estimate production, consumption, exports and the demand and supply elasticities for the 100 percent, grade B rice. The demand and supply elasticities were assumed to be -0.1 and 0.33, respectively: these parameters were from the USDA's, *A Database for Trade Liberalization Studies.* Historic production (3.43 million tons) and consumption (1.36 million tons) estimates for 100 percent, Grade B rice in Thailand were based on information from USDA personnel and that provided by researchers at the University of Arkansas. Representative exports and price for this quality of Thailand rice were estimated at 2.2 million tons and $287/ton, respectively. The F.O.B.

Bangkok price was taken from the *Rice Situation and Outlook Yearbook*, September 1998. Thailand's excess demand elasticity was estimated to be -0.93 based on the formulation offered by Bredahl, Meyers and Collins. Destination market prices were approximated with the F.O.B. Bangkok price and estimated transportation costs to these destination markets.

Results

Results are presented in three sections. The first section includes rice transportation and handling charges, and Mexico tariffs associated with inter-country trade between a selected U.S. rice supply region and a Mexico import region. This example of inter-country rice trade illustrates the key factors that drive the model solutions. The second section examines the likely effect on U.S./Mexico rice trade that will result when Mexico removes its rice tariffs in 2003 and the third section projects the likely effect on U.S./Mexico rice trade that would result from removing Mexico's phytosanitary restraints on imports of Asian rice. Discussion in sections two and three focus on model-generated results that relate changing rice prices, production and inter-country (U.S./Mexico) trade flows.

Example of U.S.-Mexican Rice Shipping and Handling Charges

The total cost of rice delivered to consumers in Mexico depends on the relative importance of farm production costs, milling costs, and transportation and handling costs in the two countries, and Mexico's rice tariffs. Industry sources state that typically, it is most efficient to mill rice near the growing location, which economizes on costs of shipping the hulls and bran by-products. Differences in tariffs that favor rough rice, or characteristics of the Mexican milling industry, may explain why current trade patterns are dominated by shipments of rough rice from the U.S. for milling in Mexico. This example provides one comparison of shipping costs, tariffs, and milling costs and their effect on the total delivered cost of U.S. rice in Mexico. This example should be viewed as a guide to the factors at play in the solution of the spatial, multi-product rice model.

Rice Milled in the United States

The example begins with rough rice produced in Arkansas, at a cost of $174.92/ton of rough rice (Table 5). Suppose this rice is milled in the United States and shipped to Mexico in milled form. A small handling charge is added, and the rice is transported to a mill at Stuttgart, Arkansas. Transportation to the mill and storage amount to $10.01/ton of rough product. The milling charge is $31.00/ton of rough rice, and $2/ton is added for grading the sacked, white rice.

By-products of milled rice are a potentially important factor in location of milling. It is assumed that rice hulls have no commercial value, but markets for bran are substantially different in the United States and Mexico, so information on value of bran is included. Bran prices in the United States were estimated to average $67.50/ton of bran during the latter 1990s. This translates into revenue for the miller, which in this analysis reduces the total cost of milling by $9.69/ton of milled rice.

The milled rice is sacked and transported to Laredo in railroad boxcars containing 70 tons. The cost per ton of milled rice is $33.89. The total cost of the product at the border is $336.10/ton of milled rice. Tariffs are calculated at 12 percent of the products value, which amounts to $40.33/ton of milled product.

Transportation within Mexico, to a final destination in Central Mexico, is estimated to cost $27.53 per ton of milled rice, shipped in sacks by boxcar. Total delivered cost of rice milled in the United States and transported to Mexico is $403.96/ton of milled rice when tariffs are in effect, or $363.63 if tariffs are assumed to be zero. In this example, the market price effects that are expected when tariffs are removed are omitted. These effects are reflected in the detailed model solutions that follow.

Rice Milled in Mexico

The alternative trade pattern considered in this example is rough rice grown in the United States that is shipped in rough form to Mexican mills, for milling and distribution in Mexico. The farm-level cost of rice production and handling is identical to that assumed before, $174.92/ton of rough rice and $1/ton handling cost. Grading at the production stage is less costly than grading after milling, at $1.00/ton of rough rice (Table 5).

Transportation of rough rice to the border is by rail, but in bulk hopper cars instead of sacks in boxcars. The transport cost per ton of rough rice is $24.00. This phase of transportation is slightly more costly, in terms of milled product, than rice milled in the United States ($35.29 per ton of milled product equivalent, compared with $33.89 per ton of sacked milled rice shipped to the border).

Tariffs are assessed on the value of the rough product at the border. The value at the border is $200.92/ton of rough rice, and duties at 6 percent *ad valorem* equal $12.06/ton of rough rice. The differential tariff on rough rice offers a cost advantage to rough rice trade. The estimated cost of the tariff in milled rice equivalent is $17.73 per ton, compared with tariffs on milled rice of $40.33 per ton.

The rough rice is shipped by rail to a mill at Pantaco, in the Federal District, for $24.85 per ton of rough rice. Rice shipped in milled form from the United States does not require this stage of transportation, which places the rough rice at a comparative disadvantage when compared with the low cost of shipping to the mill in Arkansas. Interest charges for short term storage at the mill in Mexico are $8.46, for a total cost of $33.31.

Milling charges are estimated to be lower in Mexico than in the United States, at $29.00 per ton compared with $31.00 per ton in the United States. Lower milling costs in Mexico and the higher value of bran by-products in Mexico ($92 per ton of bran, or $16.23 in revenue from bran per ton of milled rice) are factors favoring trade in rough rice. Milling yield is assumed to be slightly lower in Mexico, at 68 percent versus 70 percent for the United States.

After transportation from the mill to the demand location at Toluca are considered, total cost per ton of milled rice is $400.60/ton, compared with $403.96/ton of rice milled in the United States. Thus, a cost advantage associated with milling U.S. rough rice in Mexico, when tariffs are in place. After Mexican tariffs are removed, the relative cost advantage changes to favor rice milled in the United States. Total cost of milling in the United States and transporting the milled rice to Mexico is $363.63/ton: this cost is lower than the $382.87/ton cost associated with transporting rough rice to Mexico for milling. This example illustrates the advantage of exporting milled rice to Mexico after removal of Mexico's rice tariffs.

Effect of Removing Mexico's Rice Tariffs on U.S./Mexico Trade

The effect of removing Mexico's rice tariffs on U.S./Mexico trade is determined by contrasting a model solution that includes rice tariffs (representative of late 1990s) with a model solution that includes no rice tariffs, the anticipated situation in 2003. All model parameters *ex ante* and *ex post* tariff removal are identical except the tariff levels. In this analysis, the base model (*ex ante* tariff removal) includes tariffs representative of 1996 when Mexico's *ad valorem* tariffs on rough, brown and white rice imports were 6, 12 and 12 percent, respectively.

Ex ante Mexico's Tariff Removal (base model)

The base model (*ex ante* Mexico's tariff removal) shows U.S. production of long-grain rice to be 6.256 million tons with farm-level prices ranging from $177.52 to $182.42/ton across the South's rice producing region: weighted-average farm price for U.S. long-grain production is $178.82/ton (Table 6). Estimated revenues of long-grain rice producers is $1.11876 billion. An estimated 5.312 million tons of long-grain rough rice are transported to mills that produce white and brown rice for the domestic and export markets while remaining rough rice is exported. Consumption of long-grain white rice in the United States is estimated to be 2.0276 million tons and the weighted-average U.S. price at the packer-level of the market channel is $340.40/ton (Table 6). The base model shows an estimated 0.286 million tons of rough rice are transported by railroad (hopper cars) to border-crossing sites at Laredo and El Paso, Texas for export to Mexico: the average border-crossing price is estimated to be $201.52/ton. The principal origins for these long-grain rough rice shipments to Mexico are Arkansas and Louisiana. Additional marine-transported rough rice (0.50 mt) is exported to Mexico via the port of New Orleans: these exported supplies originate on the Arkansas and Mississippi Rivers and are transported by barge to the port at New Orleans for subsequent loading on ocean carriers by mid-stream operators. The estimated F.O.B. rough rice price for these U.S. exports at the port of New Orleans is $193.91/ton (Table 6). The base model also shows important supplies of white rice exported to Mexico by U.S. mills via overland routes. An estimated 0.0755 million tons of white rice are transported by railroads to border-crossing sites at Laredo and El Paso, Texas: the weighted-average border price for these white rice exports is $334.01/ton (Table 6).

In the base model, Mexico is estimated to produce 0.1218 million tons of long-grain rough rice at an estimated average farm-level price of $204.60/ton (Table 6). This production is concentrated in the states of Veracruz and Sinaloa. Mexico's overland imports of U.S. rough rice are milled primarily by north and central Mexico mills while imports via the port of Veracruz are processed in the state of Veracruz and neighboring states. The U.S.'s exports of white rice to Mexico enter that country via border-crossing sites: the principal destinations for these imports are northwest Mexico, and central and south Mexico. Mexico's long-grain rice production in combination with its imports of U.S. milled and rough rice generates long-grain rice supplies of 0.3866 million tons which are consumed by the Mexican population. Estimated average price of Mexico milled rice at the packer-level of the market channel is $401.12/ton (Table 6).

Ex post Mexico's Tariff Removal

Results suggest Mexico's removal of its rice tariffs in 2003 (free trade) would have a modest influence on the U.S. rice economy, provide impetus to alter the form of U.S. rice marketed to Mexico, and profoundly impact the Mexican rice economy. In general, the results conform to expectations. Removal of Mexico's rice tariffs would increase U.S. long-grain rice exports to Mexico, increase rice prices in the United States and lower rice prices in Mexico (Table 6).

Average long-grain producer prices in the United States are projected to increase from $178.82/ton (base model) to an estimated $180.43/ton with removal of all Mexican tariffs, a 0.9 percent increase in U.S. price (Table 6). The higher prices modestly increase U.S. long-grain production from 6.256 to 6.262 million tons. Revenues of U.S. producers increase from $1.11876 to $1.12991 billion, about a 1.0 percent increase. Higher prices are also reflected at the packer level where prices increase about 0.7 percent. The higher prices modestly discourage U.S. long-grain, white rice consumption which declines from an estimated 2.0276 to 2.0253 million tons (Table 6).

Removal of Mexican rice tariffs are projected to have an important influence on the form that U.S. rice is exported to Mexico. In the base model, most U.S. long-grain rice was exported to Mexico as rough rice. However, after removal of all tariffs, exports are in the form of white rice. In particular, white rice exports to Mexico are projected to increase from 0.3037 million tons (milled basis using Mexico conversion of 0.68) to 0.3254 million tons, a 7.1 percent increase in U.S. exports to Mexico. The white rice is transported by railroad (boxcars) from U.S. mills to virtually all demand regions in Mexico via border-crossing locations. Additional analysis suggests that transportation costs and higher financial costs in Mexico favor U.S. exports of white rice. The total transport costs associated with U.S. exports of milled rice to Mexico demand regions is significantly less than the transportation costs associated with U.S. exports of rough rice to Mexican mills for milling and subsequent shipment of milled rice to Mexico demand locations. Thus, the impetus to shift from rough to white rice exports *ex post* removal of Mexico's tariffs.

The increase in Mexico's imports of long-grain rice *ex post* their tariff removal lowers Mexico rice prices and production. Farm-level prices are projected to decline from $204.60/ton to $179.92/ton, a 12 percent decline in price while rough rice production is reduced from 0.1218 to 0.1071 million tons. Mexico's consumption of long-grain white rice is projected to increase from 0.3866 to 0.3982 million tons, an increase of 3 percent (Table 6). See Appendix for analysis that assumes Mexico's Morelos-type rice substitutes for its Sinaloa-type rice and the long-grain imports from the United States.

Sensitivity of Results to Lower Milling Charges in Mexico

The above analysis projects United States exports of rough rice to Mexico would cease *ex post* Mexico's removal of its rice tariffs, whereas white rice exports to Mexico would increase. The relatively high tariff on white rice imports *ex ante* Mexico's tariff removal was apparently central to Mexico's import of rough rice since, after the removal of these tariffs, Mexico became an importer of white rice. Relative milling charges in the two countries as well as transportation, handling and financial costs, and by-product prices determine location (United States versus Mexico) of the milling activity. In this analysis, milling charges in Mexico are lowered to determine the sensitivity of U.S. white rice exports to Mexico *ex post* the removal of Mexican tariffs. The estimated milling charges in the United States and Mexico are $31 and $29/ton, respectively. The sensitivity of the white rice exports to Mexican milling costs is evaluated by reducing Mexican milling charges 5, 40, and 50 percent.

The analysis suggests white rice exports to Mexico are not sensitive to lower milling charges in Mexico *ex post* tariff removal (Table 7). That is, if Mexico is without rice tariffs, comparatively dramatic reductions in Mexico milling charges are required for Mexico to import rough rice. For example, if Mexico milling charges were reduced 5 percent ($1.45/ton), an estimated 0.0233 million tons of rough rice would be exported to Mexico: these imports would comprise about 5 percent of Mexico's total rice imports (milled basis) from the United States. If Mexico milling charges were decreased a comparatively dramatic 40 percent, rough rice imports would increase to 0.04226 million tons, however, the rough rice would only comprise about 9 percent of Mexico's rice imports (milled basis). Thus, a relatively insensitive relationship between a reduction in Mexico milling charges and the increase in Mexico's imports of rough rice from the United States (Table 7).

The analysis shows the lower milling charge in Mexico would modestly increase that country's farm-level, long-grain rice price and production, and rice consumption, and lower prices at the packer-level of the market channel (Table 7). The lower prices at the packer-level of the market channel modestly increase Mexican rice consumption. The lower milling charges in Mexico modestly reduces U.S. rice exports to that country. For example, on a milled rice basis, U.S. rice exports to Mexico decline from 0.3254 million tons to 0.3248 million tons with a 5 percent reduction in Mexican milling costs. In general, lower milling charges in Mexico have almost no impact on the U.S. rice economy. See Appendix for analysis that assumes Mexico's Morelos-type rice substitutes for its Sinaloa-type rice and long-grain rice imports from the United States.

Effect of Removing Mexico's Asian Rice Restraints on U.S./Mexico Trade

Thailand, the largest exporter of rice in the world, has been effectively banned from the Mexico rice market by phytosanitary concerns since the mid-1990s. However, some believe political pressure from the World Trade Organization may force Mexico to rescind its restraint and/or Thailand may eventually market a rice that is free of the selected pests. Thailand's 100 percent, grade B long-grain rice is viewed as a close substitute for U.S.'s No. 2 long-grain, 4% broken rice product. In this analysis, efforts are made to determine the ability of Thailand to penetrate the Mexican rice market. It is assumed that NAFTA provisions have been fully implemented, i.e., Mexican rice tariffs do not apply on imports from the United States, whereas Mexican tariffs may be applied to imports from Thailand. During 1994-1998, Thailand's F.O.B. port price averaged about $42/ton less than the comparable U.S. price, however, as a result of Thailand currency devaluations and other factors, the spread between U.S. and Thailand F.O.B. prices have widened to as much as $135/ton in selected time periods (Nathan Childs). In this analysis, alternative U.S./Thailand F.O.B. port price spreads are evaluated to determine Thailand's ability to penetrate the Mexican rice market: in addition, the analysis incorporates selected ship rates linking Thailand to Mexican ports and alternative Mexican tariffs.

Table 8 shows Mexican imports of Thailand and U.S. white rice and U.S. and Mexican farm-level prices and production at alternative U.S./Thailand F.O.B. port price spreads, selected Thailand to Mexico ship rates, and various Mexican *ad valorem* tariffs on Thailand rice imports. In this analysis, Mexico levies no tariffs on imports of U.S. rice, i.e., the analysis is considering the year 2003 and beyond. At the historic largest U.S./Thailand price spread ($135/ton) and lowest considered ship rate ($44/ton) and zero Mexican tariffs on Thai rice, Thailand is projected to supply about 47 percent (0.1596 million tons) of Mexico's white rice imports. The remainder (0.1809 million tons) is supplied by the United States. With this scenario, Mexico is projected to produce 0.0973 million tons of long-grain rough rice at an average farm-level price of $162.35/ton, while U.S. production and farm-level price is projected to be 6.202 million tons of long-grain rough rice and $164.34/ton, respectively. Mexican tariffs on imports of Thailand rice have an important influence on Mexican production and price as well as U.S. rice price. If Mexico increases its *ad valorem* tariff to 5 percent on Thailand rice, U.S. white rice exports to Mexico are projected to increase from 0.1809 to 0.2844 million tons while U.S. farm-level price increases from $164.34 to $175.89/ton. Results show Thailand would be excluded from the Mexican market if Mexico were to levy a 10 percent *ad valorem* tariff on its product (Table 8). And, when Thailand is excluded from the Mexican market, U.S. prices are projected to increase to $180.43/ton, an increase of $16.09/ton above the price level ($164.34) associated with a zero Mexican tariff. Thus, Mexican tariffs on its non-U.S. rice imports have an important influence on rice prices in the United States. See Appendix for analysis that assumes Mexico's Morelos-type rice substitutes for its Sinaloa-type rice and long-grain imports from the United States.

In general, Thailand appears to be a threat to U.S.'s role in the Mexican market when the U.S./Bangkok F.O.B. port price spread is $115/ton or greater and the Thailand-to-Mexico ship rates do not exceed $54/ton. However, if Mexico were to maintain at least a 10 percent *ad valorem* tariff on Thailand imports, the U.S.'s role in the Mexican market could be preserved at any analyzed price spread and ship rate. Current Mexican provisions indicate they would levy a 20 percent *ad valorem* tariff on rice imports from Thailand, if Mexico were to lift its current restraints on Thai rice.

Summary and Conclusion

This study attempts to identify the effect on U.S./Mexico rice trade (1) that will result when Mexico removes its tariffs on U.S. rough, brown and white rice exports in 2003, and (2) if Mexico were to remove its current phyosanitary restraints on Thailand rice imports. To carry out the analysis, a spatial, multi-product model was developed. The model features regional rice supplies and demands in the United States and Mexico as well as handling, milling, and transportation charges unique to rough, brown and white rice. The model includes demands, supplies, and milling, handling and transport charges representative of the late 1990s. Model validation showed actual prices, production and product flows were closely approximated by the model. Thus, it was judged appropriate to carry out the proposed analysis. The effect of removing Mexico's rice tariffs was determined by contrasting model solutions that included rice tariffs representative of 1996 with a model solution that included no Mexican rice tariffs, the anticipated situation in 2003. To determine the ability of Thailand to penetrate the Mexican rice market, historic U.S./Thailand F.O.B. port price spreads were evaluated in combination with alternative Mexican tariffs on Thailand rice and estimated ship rates linking Thailand to Mexico.

Results suggest Mexico's removal of all rice tariffs in 2003 would have a modest influence on the U.S. rice economy, provide impetus to alter the form that U.S. rice is exported to Mexico, and profoundly impact the Mexican rice economy. Farm-level prices in the United States are projected to increase about 0.9 percent and total producer revenues about 1.0 percent when Mexico removes all rice tariffs. In contrast, Mexican production of long-grain rice is projected to decline and farm-level prices are reduced a comparatively large 12 percent. Further, the analysis suggests that removal of Mexican tariffs will provide impetus to alter the product form that U.S. rice is exported to Mexico. Comparatively low tariffs on Mexico's rough rice imports from the U.S. have favored U.S. exports of this product form. However, with tariff removal on all product forms, white rice becomes the most efficient means for Mexico to import U.S. rice. Thus, the opportunity for additional value-added output by U.S. rice millers. Sensitivity analysis showed lower milling charges in Mexico would modestly increase Mexico's imports of rough rice.

Additional analysis suggests Thailand is a modest threat to U.S.'s current dominance in the Mexican rice import market. Only at historically high U.S./Bangkok F.O.B. port price spreads and comparatively low Thailand-to-Mexico ship rates would Thailand have a presence in the Mexican market. Further analysis indicates U.S.'s role in the Mexican market could be preserved if Mexico were to levy at least a 10 percent *ad valorem* tariff on any potential Thai imports. Current Mexican provisions indicate any imports from Thailand would be levied a 20 percent *ad valorem* tariff.

A caveat is offered regarding the Thailand analysis. Current model construction does not fully represent potential shifts that may occur in other (e.g. Saudi Arabia) import markets as changes take place with respect to Mexico. Previous research suggests this may impair the accuracy of these results. It is speculated that the presented results may be too conservative with respect to Thailand's ability to access the Mexican market, i.e., the analysis underestimates Thailand as a competitor in the Mexican market.

In summary, rice provisions of NAFTA have a positive influence on U.S. rice producers and millers by increasing U.S. producer prices and revenues and providing impetus for increased milled rice exports to Mexico. The analysis suggests Thailand is a moderate threat to U.S.'s dominance of the Mexican rice market.

Glossary

Brokens: Kernels of rice that are less than three-fourths of the length of the whole kernel; a by-product of the milling process.

Brown rice: Whole or broken kernels of rice from which the hull has been removed. Brown rice may be eaten as is, or may be milled into regular-milled white rice. The light brown color of brown rice is caused by the presence of seven bran layers.

Green rice: Rice in the form immediately after harvesting, prior to undergoing a drying process.

Head rice: Whole kernels of milled rice. To be categorized as head rice, the length of the kernel must be at least three-fourths the length of the whole kernel.

Long-grain rice: Rice that is long and slender in shape, as much as four to five times as long as it is wide. When cooked, the grains tend to remain separate and are light and fluffy.

Paddy rice: See rough rice.

Parboiled rice: Rough rice soaked in warm water under pressure, steamed and dried before milling. Parboiled rice cooks up fluffier and sticks together less than does regular-milled white rice.

Regular-milled white rice: The rice product produced after the hull, bran layers and germ have been removed.

Rice hulls: The outer woody covering of the rice kernel.

Rice bran: The outer cuticle layer and the germ of the rice grain which is removed in the milling process.

Rough rice: Also called paddy rice, is harvested, whole-kernel rice with the hull remaining. Rough rice is sold to the mill for dehulling and polishing.

White rice: See regular-milled white rice.

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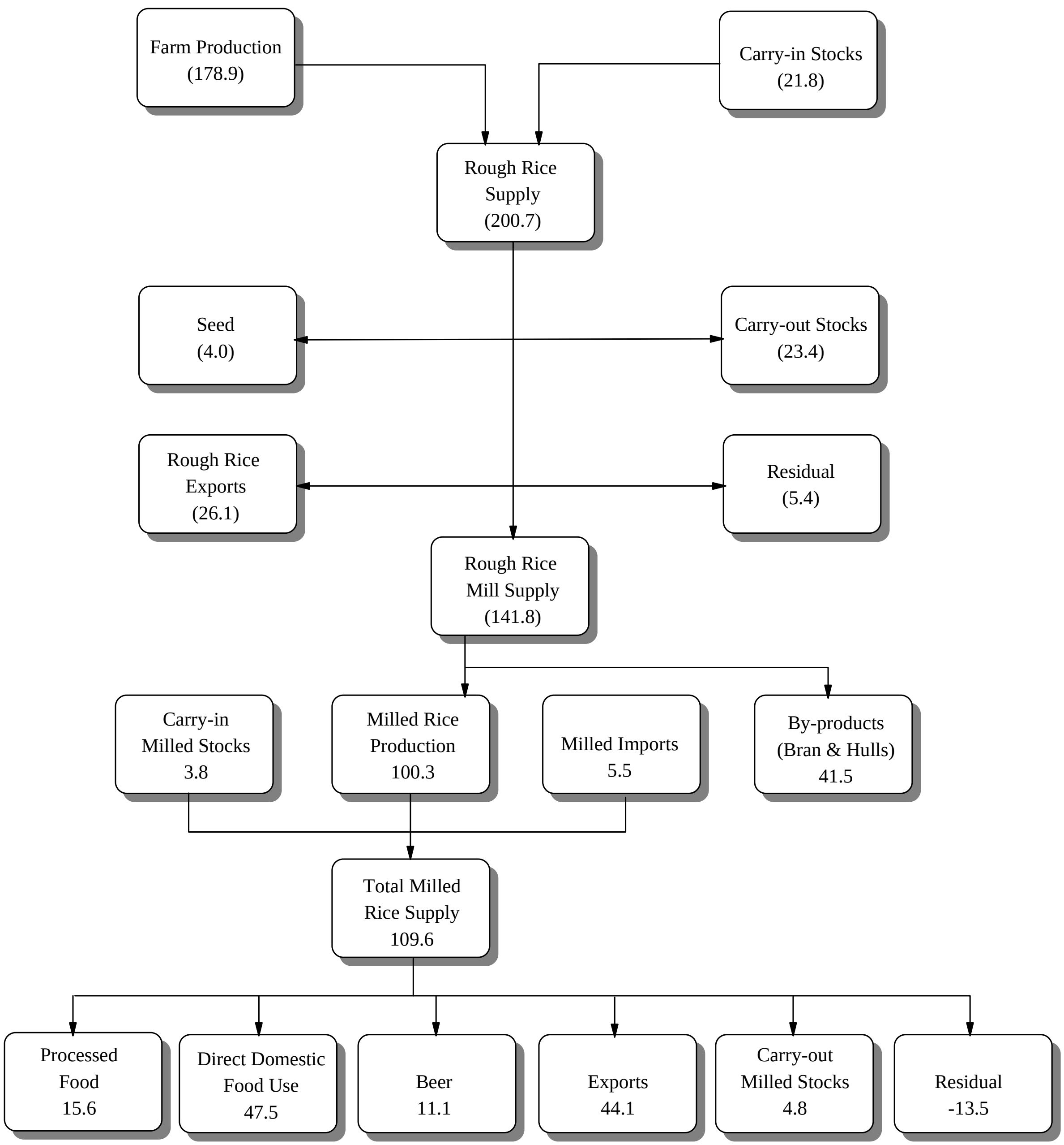
Figure 1. U.S. Marketing System for Rice 1997-1998.



August - July, Million cwt. Figures in parentheses are rough basis, others (except by-products) are milled basis.

Figure 2. Map of United States Rice Production, 1998 (tons of production/county).

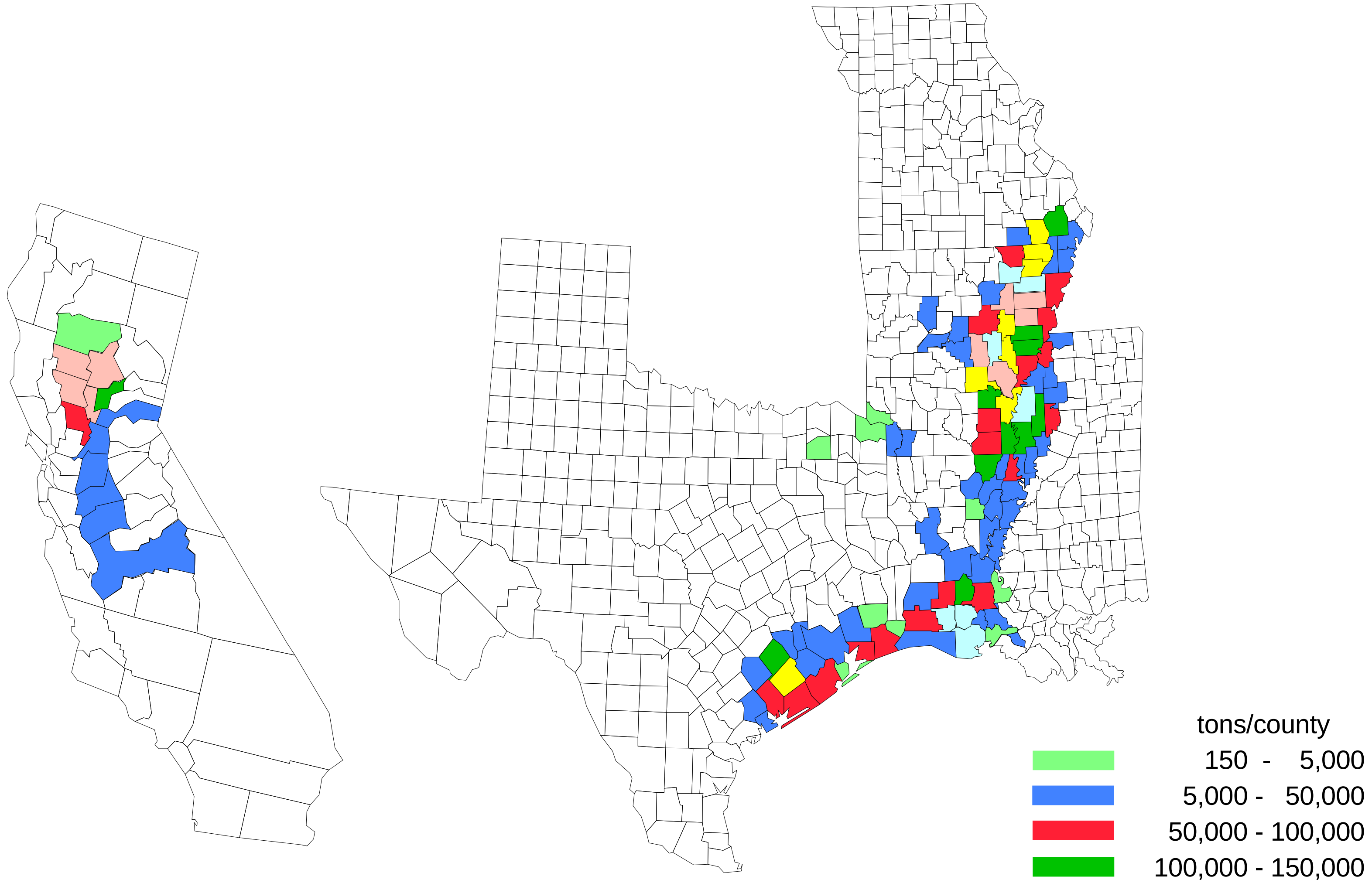


Figure 3. Map of Mexico Rice Production, 1996 (tons of production/state).

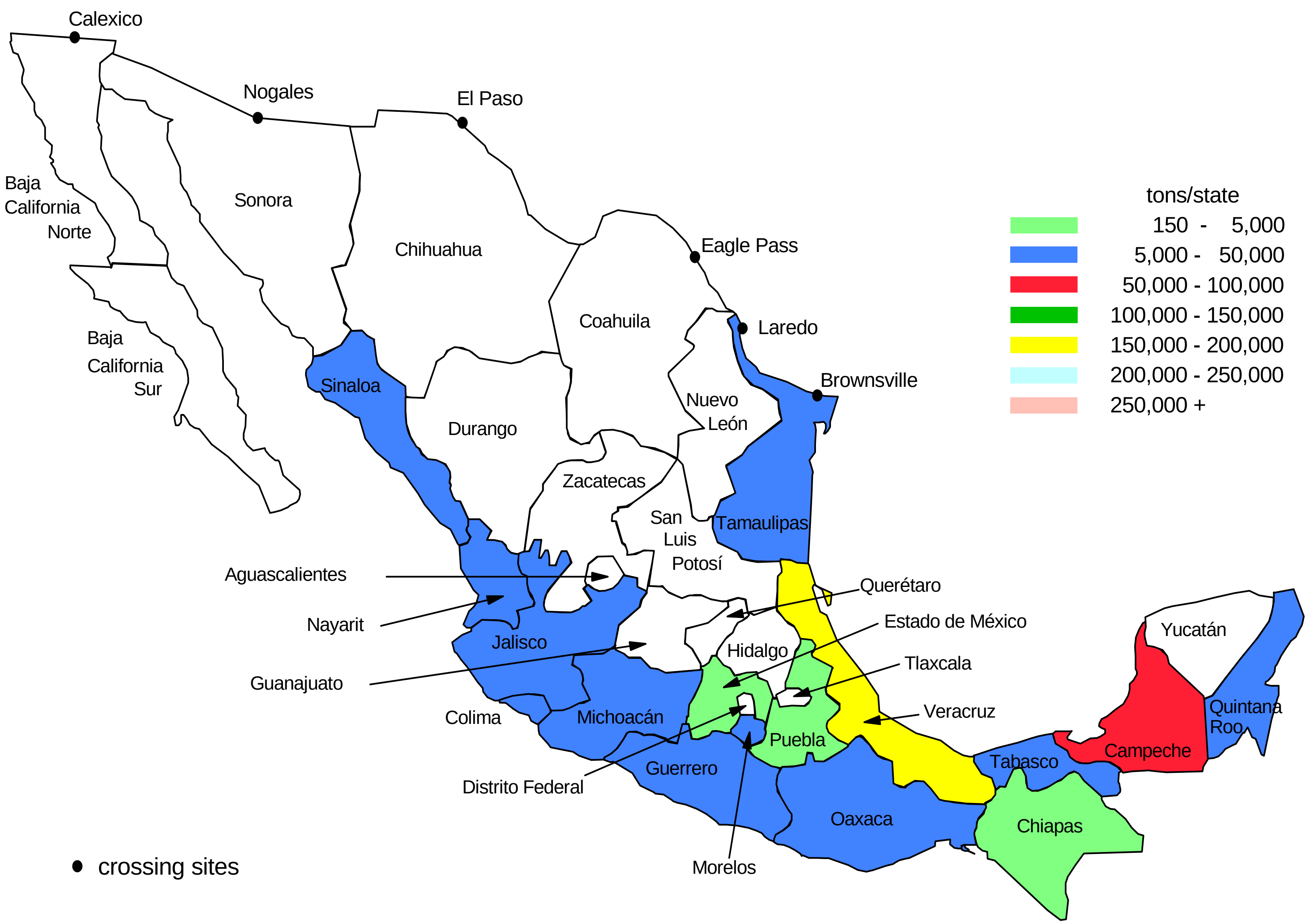


Table 1. Subscripts, Parameters and Variables Included in Formulated Rice Model.

Subscripts:	
a	Mexico excess supply regions (a = 1, 2, 3, ..., m)
b	Barge loading locations (b = 1, 2, 3, 4, 5)
c	U.S. mills (c = 1, 2, 3, ..., m)
d	Foreign importing regions (d = 1, 2,)
e	Border U.S.-Mexico transhipment locations (e = 1, 2, 3, 4, 5)
f	Foreign exporting region (f = 1)
g	Mexican ports (g = 1, 2, 3, 4, 5)
h	Mexico demand regions (h = 1, 2, 3,...., m)
i	U.S. excess supply regions (i = 1, 2, 3, ..., m)
j	U.S. excess demand regions (j = 1, 2, 3, ..., m)
k	Rice products {k = 1, 2, r = 3}
l	Mexican mills (l = 1, 2, 3, ..., m)
m	Modes of transportation (m = 1, 2, 3, .., m)
n	By products (n = 1, 2)
p	U.S. ports (p = 1, 2, 3, 4)
r	rough
Parameters:	
C	Transportation, storage, financial charge and handling cost per short ton for truck, railroad, barge and ship modes as appropriate
V	Mill yields, products and by products
Variables:	
S_{ir}	U.S. excess supply regions (rough rice)
S_{fk}	Foreign excess supply regions (white rice)
S_{qr}	Mexico excess supply regions (rough rice)
D_{jk}	U.S. excess demand regions (k_1 = brown rice; k_2 = white)
D_{dk}	Foreign excess demand regions {k_1 = brown rice; k_2 = white; (r = rough rice)}
T	Grain flow in short tons between nodes

Table 2. U.S. Long-Grain Rice Supply Regions in Model.

State	Origin Site	Counties
Arkansas	Brinkley, Arkansas	Crittenden, Cross, Lee, Lonoke, Monroe, Phillips, Prairie, Saint Francis, Woodruff
	Jonesboro, Arkansas	Clay, Craighead, Greene, Independence, Jackson, Lawrence, Mississippi, Poinsett, Randolph, White
	Little Rock, Arkansas	Faulkner, Perry, Pope, Pulaski, Yell
	Montrose, Arkansas	Ashley, Chicot, Desha, Drew
	Stuttgart, Arkansas	Arkansas, Jefferson, Lincoln
	Texarkana, Arkansas	Bowie, Hopkins, Lafayette, Lamar, Little River, Miller
California	Stockton, California	Butte, Colusa, Glenn, Sacramento, Sutter, Tehama, Yolo, Uba, Fresno, Merced, San Joaquin, Stanislaus
Louisiana	Crowley, Louisiana	Acadia, Allen, Beauregard, Calcasieu, Cameron, Evangeline, Jefferson, Rapides, Vermillion
	Lafayette, Louisiana	Iberia, Lafayette, Saint Martin
	Marksville, Louisiana	Avoyelles, Catahoula, Concordia, Natchitoches, Pointe Coupee, Saint Landry
	Mer Rouge, Louisiana	Caldwell, East Carroll, Franklin, Madison, Morehouse, Ouachita, Richland, Tensas, West Carroll
Mississippi	Clarksdale, Mississippi	Bolivar, Coahoma, Desoto, Panola, Quitman, Tallahatchie, Tate, Tunica
	Cleveland, Mississippi	Humphrey, Issaquena, Leflore, Sharkey, Sunflower, Washington, Yazoo
Missouri	Poplar Bluff, Missouri	Butler, Dunklin, New Madrid, Pemiscot, Ripley, Stoddard
Texas	Bay City, Texas	Brazoria, Galveston, Matagorda,
	Beaumont, Texas	Chambers, Hardin, Harris, Jefferson, Liberty, Orange
	Chesterville, Texas	Austin, Calhoun, Colorado, Ft. Bend, Jackson, Lavaca, Victoria, Waller, Wharton

Table 3. White and Brown Rice Demand Regions in U.S. Portion of Model.

Region	Demand Center	States
Pacific Region	Sacramento, California	California, Oregon, Washington, Hawaii, Alaska
Mountain	Salt Lake City, Utah	Montana, Idaho, Wyoming, Nevada, Utah, Colorado, Arizona, New Mexico
West North Central	Des Moines, Iowa	Minnesota, North Dakota, South Dakota, Nebraska, Iowa, Kansas, Missouri
West South Central	Dallas, Texas	Texas, Oklahoma, Arkansas, Louisiana
East North Central	Chicago, Illinois	Ohio, Indiana, Illinois, Mississippi, Wisconsin
East South Central	Nashville, Tennessee	Kentucky, Tennessee, Alabama, Mississippi
New England	Boston, Massachusetts	Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut
Middle Atlantic	New York, New York	New York, Pennsylvania, New Jersey
South Atlantic	Durham, North Carolina	Delaware, Maryland, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida

Table 4. White Rice Demand Regions in Mexico Portion of Model.

Region	Demand Center	States
Northwest	Culican, Sinaloa	Baja California Norte, Baja California Sur, Sonora, Sinaloa
North	Torreon, Coahuila	Chihuahua, Durango, Coahuila
Northeast	Monterrey, Nuevo Leon	Nuevo Leon, Tamaulipas
North Central	Guanajuato, Guanajuato	Zacatecas, Aguascalientes, San Luis Potosi, Guanajuato, Queretaro
Western	Guadalajara, Jalisco	Nayarit, Jalisco, Colima, Michoacan
Central	Pantaco, Distrito Federal Toluca, Mexico	Distrito Federal, Mexico, Morelos, Tlaxcala, Hidalgo, Puebla
Gulf	Cordoba, Veracruz	Veracruz, Tabasco
South Pacific	Oaxaca, Oaxaca	Guerrero, Oaxaca, Chiapas
Yucatan Peninsula	Merida, Yucatan	Yucatan, Campeche, Quintana Roo

Table 5. Estimated Rice Transportation and Handling Charges, and Mexican Tariffs Associated with Rice Trade between Brinkley, Arkansas and Toluca, Mexico, Tariffs as of 1996.

	Ex Ante Tariff Removed		*Ex Post* Tariff Removed	
Rice milled in the U.S. [1]	Rough $/ton	Milled $/ton	Rough $/ton	Milled $/ton
Farm cost	$174.92	$249.89	$174.92	$249.89
Handling	$1.00	$1.43	$1.00	$1.43
Transport to mill, (Stuttgart) and interest	$10.01	$14.30	$10.01	$14.30
Milling	$31.00	$44.29	$31.00	$44.29
Subtotal	$216.93	$309.90	$216.93	$309.90
Grading		$2.00		$2.00
Revenue from bran ($67.50 per ton)		($9.69)		($9.69)
Transport to Laredo, railcar of 70 tons sacked		$33.89		$33.89
Subtotal		$336.10		$336.10
Tariff (12% on milled)		$40.33		$0.00
Transport to demand location, Toluca		$27.53		$27.53
Total		**$403.96**		**$363.63**

Table 5. Continued.

Rice milled in Mexico [2]	*Ex Ante* Tariff Removed		*Ex Post* Tariff Removed	
	Rough $/ton	Milled $/ton	Rough $/ton	Milled $/ton
Farm cost	$174.92	$257.24	$174.92	$257.24
Handling	$1.00	$1.47	$1.00	$1.47
Grading	$1.00	$1.47	$1.00	$1.47
Transport to Laredo, 80 ton hopper car	$24.00	$35.29	$24.00	$35.29
Subtotal	$200.92	$295.47	$200.92	$295.47
Tariff (6% rough)	$12.06	$17.73	$0.00	$0.00
Transport to mill, Pantaco, D.F. (+ interest 1.5 mos.)	$33.31	$48.99	$33.31	$48.99
Milling	$29.00	$42.65	$29.00	$42.65
Subtotal	$275.29	$404.83	$263.23	$387.10
Revenue from bran ($92 per ton)		($16.23)		($16.23)
Transport to demand location, Toluca		$12.00		$12.00
Total		**$400.60**		**$382.87**

[1] U.S. milling yield is 0.70.
[2] Mexico milling yield is 0.68.

Table 6. Estimated Effects of Removing Mexico’s Rice Tariffs on U.S./Mexico Rice Trade. [1]

	Ex Ante Tariff Removed		*Ex Post* Tariff Removed		% Change	
United States:						
Farm Price ($/short ton, rough)	$178.82		$180.43		0.90%	
Production (million tons, rough)	6.2563		6.2623		0.10%	
Packer Price ($/short ton, white)	$340.40		$342.72		0.68%	
Consumption (million tons, white)	2.02760		2.02535		-0.12%	
Mexico:						
Farm Price ($/short ton, rough)	$204.60		$179.92		-12.06%	
Production (million tons, rough)	0.12182		0.10707		-12.01%	
Packer Price ($/short ton, white)	$401.12		$365.05		- 8.99%	
Consumption (million tons, white)	0.38659		0.39822		3.01%	
Flows to Mexico:	Quantity	Price	Quantity	Price	Quantity	Price
	million tons	$/ton	million tons	$/ton	% change	% change
Rough - border	0.28564	$201.52	0	n.a.	-100.00%	n.a.
Rough - ocean	0.05003	$193.91	0	n.a.	-100.00%	n.a.
White - border	0.07550	$334.01	0.32541	$336.57	302.10%	0.77%
White - ocean	0	n.a.	0	n.a.	n.a.	n.a.

[1] In this analysis, only long-grain rice production and consumption in Mexico are included in the Mexico portion of the model. It is assumed that Mexico’s Morelos-type rice does not substitute for the Sinaloa-type and long-grain rice imports from the U.S. and vice versa.

Table 7. Estimated Effects on U.S./Mexico Rice Trade of Lower Mexico Milling Charges. [1]

	Ex Post Tariff Removed		5% Reduction in Mexican charges		40% Reduction in Mexican charges		50% Reduction in Mexican charges	
United States:								
Farm Price ($/short ton, rough)	$180.43		$180.42		$180.07		$180.35	
Production (million tons, rough)	6.26235		6.26231		6.261007		6.262076	
Packer Price ($/short ton, white)	$342.72		$342.70		$342.15		$342.55	
Consumption (million tons, white)	2.02526		2.025281		2.02583		2.025429	
Mexico:								
Farm Price ($/short ton, rough)	$179.92		$181.36		$191.13		$193.70	
Production (million tons, rough)	0.10707		0.107932		0.113778		0.115307	
Packer Price ($/short ton, white)	$365.05		$365.03		$364.40		$363.76	
Consumption (million tons, white)	0.39822		0.398229		0.39843		0.398636	
Flows to Mexico:	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
	million tons	$/ton	million tons	$/ton	million tons	$/ton	million tons	$/ton
Rough - border	0	n.a.	0.02327	$193.31	0.042258	$202.41	0.146027	$203.05
Rough - ocean	0	n.a.	0	n.a.	0	n.a.	0.056104	$195.44
White - border	0.32541	$336.57	0.309014	$336.39	0.292325	$335.98	0.182778	$336.32
White - ocean	0	n.a.	0	n.a.	0	n.a.	0	n.a.

[1] In this analysis, only long-grain rice production and consumption in Mexico are included in the Mexico portion of the model. It is assumed that Mexico's Morelos-type rice does not substitute for the Sinaloa-type and long-grain rice imports from the U.S. and vice versa.

Table 8. Effects of Mexico's Rice Imports from Thailand on U.S./Mexico Trade at Alternative U.S./Thailand Price Spreads, Ship Rates, and Mexican Tariffs on Thailand Rice Imports. [1]

		Mexico					United States	
U.S./Thailand Price Spread	Ship Rate	*Ad Valorem* Tariff Rate	Imports from Thailand	Imports from U.S.	Mexico Production	Mexico Farm Price	U.S. Production	U.S. Farm Price
----------$/ton------------		%	-------------------------tons-------------------------			$/ton	tons	$/ton
135	44	0	0.15963	0.18095	0.0973	162.35	6.202	164.34
135	44	5.00	0.04537	0.284388	0.1043	173.82	6.245	175.89
135	44	7.50	0.03064	0.297428	0.1053	176.91	6.250	177.33
135	44	10.00	0.0	0.3254	0.1071	179.92	6.262	180.43
135	54	0	0.06615	0.2655	0.1029	171.68	6.237	173.80
135	54	5.00	0.0	0.3254	0.1071	179.92	6.262	180.43
115	44	0	0.0415	0.2879	0.1045	174.21	6.247	176.28
115	44	5.00	0.0	0.3254	0.1071	179.92	6.262	180.43
115	54	0	0.0204	0.3067	0.1059	177.91	6.254	178.36
115	54	5.00	0.0	0.3254	0.1071	179.92	6.262	180.43

[1] In this analysis, only long-grain rice production and consumption in Mexico are included in the Mexico portion of the model. It is assumed that Mexico's Morelos-type rice does not substitute for the Sinaloa-type and long-grain rice imports from the U.S. and vice versa.

Appendix

Table A1. Estimated Effects of Removing Mexico's Rice Tariffs on U.S./Mexico Rice Trade. [1]

	Ex Ante Tariff Removed		*Ex Post* Tariff Removed		% Change	
United States:						
Farm Price ($/short ton, rough)	$176.07		$180.71		2.63%	
Production (million tons, rough)	6.24610		6.26337		0.28%	
Packer Price ($/short ton, white)	$336.44		$343.11		1.98%	
Consumption (million tons, white)	2.03150		2.02488		-0.33%	
Mexico:						
Farm Price ($/short ton, rough)	$195.90		$174.53		-10.91%	
Production (millions tons, rough)	0.44530		0.39648		-10.96%	
Packer Price ($/short ton, white)	$394.30		$362.60		-8.04%	
Consumption (million tons, white)	0.58218		0.59748		2.63%	
Flows to Mexico:	Quantity	Price	Quantity	Price	Quantity	Price
	million tons	$/ton	million tons	$/ton	% change	% change
Rough - border	0.31513	$198.77	0	n.a.	-100.00%	n.a.
Rough - ocean	0	n.a.	0	n.a.	-100.00%	n.a.
White - border	0.06508	$330.09	0.32788	$337.03	403.81%	2.10%
White - ocean	0	n.a.	0	n.a.	n.a.	n.a.

[1] In this analysis, all rice production and consumption in Mexico are included in the Mexico portion of the model. It is assumed that Mexico's Morelos-type rice substitutes for the Sinaloa-type and long-grain rice imports from the U.S. and vice versa.

Table A2. Estimated Effects on U.S./Mexico Rice Trade of Lower Mexico Milling Charges. [1]

	Ex Post Tariff Removed		5% Reduction in Mexican charges		40% Reduction in Mexican charges		50% Reduction in Mexican charges	
United States:								
Farm Price ($/short ton, rough)	$180.71		$180.55		$179.24		$179.09	
Production (million tons, rough)	6.26337		6.262784		6.257909		6.257361	
Packer Price ($/short ton, white)	$343.11		$342.88		$340.97		$340.75	
Consumption (million tons, white)	2.02488		2.025102		2.027006		2.027219	
Mexico:								
Farm Price ($/short ton, rough)	$174.53		$175.82		$184.55		$186.99	
Production (million tons, rough)	0.39648		0.399438		0.41941		0.42499	
Packer Price ($/short ton, white)	$362.60		$362.38		$360.33		$359.45	
Consumption (million tons, white)	0.59748		0.597592		0.598582		0.599001	
Flows to Mexico:	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
	million tons	$/ton	million tons	$/ton	million tons	$/ton	million tons	$/ton
Rough - border	0	n.a.	0.023268	193.435	0.05202	201.585	0.143741	201.784
Rough - ocean	0	n.a.	0	n.a.	0	n.a.	0	n.a.
White - border	0.32788	337.03	0.310152	336.811	0.27801	334.887	0.212264	334.623
White - ocean	0	n.a.	0	n.a.	0	n.a.	0	n.a.

[1] In this analysis, all rice production and consumption in Mexico are included in the Mexico portion of the model. It is assumed that Mexico's Morelos-type rice substitutes for the Sinaloa-type and long-grain rice imports from the U.S. and vice versa.

Table A3. Effects of Mexico's Rice Imports from Thailand on U.S./Mexico Trade at Alternative U.S./Thailand Price Spreads, Ship Rates, and Mexican Tariffs on Thailand Rice Imports. [1]

		Mexico					United States	
U.S./Thailand Price Spread	Ship Rate	*Ad Valorem* Tariff Rate	Imports from Thailand	Imports from U.S.	Mexico Production	Mexico Farm Price	U.S. Production	U.S. Farm Price
---------$/ton-------------		%	-----------------------tons-------------------------			$/ton	tons	$/ton
135	44	0	0.2004	0.1687	0.3548	156.29	6.198	163.07
135	44	5.0	0.0665	0.2761	0.3815	167.98	6.242	174.97
135	44	7.5	0.0293	0.3053	0.3897	171.54	6.254	178.20
135	44	10.0	0.0	0.3278	0.3965	174.53	6.263	180.71
135	54	0	0.0735	0.2706	0.3799	167.30	6.240	174.36
135	54	5.0	0.0	0.3278	0.3965	174.53	6.263	180.71
115	44	0	0.0612	0.2803	0.3826	168.44	6.244	175.44
115	44	5.0	0.0	0.3278	0.3965	174.53	6.263	180.71
115	54	0	0.0133	0.3173	0.3936	173.29	6.259	179.54
115	54	5.0	0.0	0.3278	0.3965	174.53	6.263	180.71

[1] In this analysis, all rice production and consumption in Mexico are included in the Mexico portion of the model. It is assumed that Mexico's Morelos-type rice substitutes for the Sinaloa-type and long-grain rice imports from the U.S. and vice versa.