FREE TRADE AREA OF THE AMERICAS:

EFFECTS ON THE U.S. SUGAR INDUSTRY

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Free Trade Area of the Americas: Effects on the U.S Sugar Industry

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ABSTRACT

Carlson-Goodman, Melissa Joy; M.S.; Department of Agribusiness and Applied Economics; College of Agriculture, Food Systems, and Natural Resources; North Dakota State University; November 2002. Free Trade Area of the Americas: Effects on the U.S. Sugar Industry. Major Professors: Drs. Won W. Koo and Eric DeVuyst.

The potential Free Trade Area of Americas (FTAA) agreement may have negative effects on the U.S. sugar industry. South and Central American and Caribbean sugar producers have great capabilities to produce sugar at much lower costs than that of the United States. If the FTAA allows large-scale trade liberalization among these countries, the U.S. sugar industry may be in danger. A spatial equilibrium model is used to determine the short- and long-run effects of this trade agreement under several liberalization scenarios.

Exporting countries have rather inelastic export supply equations in the short run, indicating small increases in exports immediately after FTAA trade policy is regulated. The U.S. domestic sugar industry experiences positive short-run effects in alternative trade flow scenarios where either Brazil or Mexico is restricted. Large-scale liberalization, by unlimited and zero quotas for major foreign sugar exporters, indicates the most harmful effects for U.S. producers. As the trade environment becomes more liberalized, U.S. consumers experience increasingly positive benefits in the short run.

Long-run results include larger supply elasticities for foreign export supply equations, increasing foreign sugar export potential. When all foreign sugar exporters are allowed unlimited exports in the long run, exports increase most. Total U.S. sugar production increases as competitive regions increase and non-competitive regions

decrease production. Consumers receive most benefit under long-run trade implications of an FTAA.

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CHAPTER I. INTRODUCTION

Problem Statement

Less than 14% of the U.S. sugar supply was accounted for by foreign imports in 2000 according to United States Department of Agriculture (USDA) statistics (USDA-ERS 2001). However, trade liberalization policies are allowing increases in sugar imports. The Uruguay Round Agreement (URA) of the General Agreement on Tariffs and Trade (GATT) required the United States to increase its sugar import levels by imposing a higher minimum quota level. The North American Free Trade Agreement (NAFTA) allows complete free sugar trade with Mexico in 2008 and also quota-allocated sugar syrup imports from Canada. As sugar supply on the U.S. market increases, downward pressure may be placed on domestic price and also on price supports upheld by the U.S. sugar program.

An additional potential trade agreement, the Free Trade Area of Americas (FTAA), which is scheduled to be complete by 2005, may have negative effects on the U.S. domestic sugar industry. An FTAA may eliminate tariffs among the 34 Western Hemisphere countries and has major implications for the sugar industry. According to Haley's (2002) study of an FTAA's consequences for sugar, in the event of tariff-free import increases from some of the world's largest sugar producers, namely Brazil, U.S. prices and production are expected to decline significantly.

The reasoning behind an FTAA largely stems from the United States interest in opening opportunities for trade and investment developing in Latin American countries. An FTAA will attempt to build economic and political stability to the hemisphere, in turn, increasing trade. The United States hopes to increase its agricultural exporting to these countries, namely the Andean nations, including Brazil, Argentina, Uruguay, and

Paraguay, where less than 10% of U.S. exports have gone in the past (Burfisher and Link 2000). The Economic Research Service (ERS) predicts that U.S. participation in an FTAA would be positive economically and would be significantly worse off if other countries formed an FTAA excluding the United States. The ERS also predicts that the effects of an FTAA will be relatively small, due to the fact that trade liberalization agreements are already in place through the North American Free Trade Agreement (NAFTA) and the MERCOSUR, a trade agreement among Argentina, Brazil, Paraguay, and Uruguay, except for a few U.S. commodities (Burfisher and Link 2000). Sugar is one of the commodities found through preliminary research of an FTAA to be highly impacted (Burfisher and Link 2000).

Possible problems the United States may face from an FTAA are numerous. Roney (1999) reports several areas where the domestic sugar industry may be threatened: unstable exchange rates in developing South and Central American countries, uneven labor and environmental standards, and inability to monitor individual country compliance with agreement terms. Other issues may arise from a lack of harmonized tariff among nations as the many FTAA countries hold WTO imposed *ad valorem* import tariffs inconsistent with that of the U.S. tariff system (Roney 1999). Finally, the American Sugar Alliance (ASA) predicts that all FTAA countries will have to protect their domestic industries from Brazil considering Brazil's immense production capacity and internal price supports.

Need for Study

Many studies in the past have used econometric analysis to determine market conditions, which does not allow for optimization of trade flows obtained from a spatial equilibrium model. A spatial equilibrium model accounts for the shocks of imports to the market system and appropriately determines trade flows.

There are few studies available on the effects of an FTAA. Many of the possibilities for its impacts have not yet been explored. Previous studies performed on free trade agreements have focused on impacts to the sugar market as a whole. This study involves several scenarios that determine results for both the United States and its regional production. This study includes impacts on regional U.S. production areas, specifically the Red River Valley.

In North Dakota alone, the sugar and corn sweetener industry provides 8000 jobs and pumps $694 million into the local economy (ASA Online 2002). If an FTAA causes this area to cease sugar production, the effects would be negative and widespread across the region. This project is useful for sugar producers, processors, and government legislators to evaluate the future of the U.S. sugar market under a regional free trade environment.

Objectives

The overall goal of this project is to analyze the impacts of an FTAA on the U.S. sugar industry, giving special attention to the sugar beet market in the Red River Valley region. Specific objectives of the study are

(1) To identify potential impacts of additional sugar imports from South and Central American and Caribbean sugar producers under several potential FTAA scenarios through tariff and quota liberalization.

(2) To evaluate the regional effects on the Red River Valley sugar beet industry with respect to price, production, and producer surplus.

Methodology

A spatial equilibrium model based on quadratic programming is developed with a General Algebraic Modeling System (GAMS) (Brooke et al. 1998) to optimize trade flows under an FTAA. The objective function of the model is to maximize the sum of U.S. sugar consumer welfare, producer welfare, and sugar exporting countries' surplus minus transportation costs, processing costs, handling costs, processor rents, and tariffs costs. The objective function is subject to a set of linear constraints to find optimal trade flows: tariffs and quotas, transportation costs, handling costs, and processing costs.

For this study, 10 regions are used to summarize 26 exporting countries for sugar production in the model. South and Central America are grouped into three South American regions and two Central American regions. Other exporting countries include Mexico, the Caribbean, Australia, South Africa, and the Philippines. Non-FTAA members are included to accurately capture world sugar trade flows. Additionally, the United States is divided into seven production regions: the Red River Valley, Great Lakes, Upper Great Plains, and the Far West summarize beet production, while Florida, Louisiana, and Texas are used for cane.

The model supply and demand parameter values are derived from an econometric sugar simulation model (Benirschka, Koo, and Lou 1996). Technical data, such as consumption, production, net exports, tariffs, quotas, and processing facility capacities, are utilized from various issues of USDA *Sugar and Sweetener Situation and Outlook* reports. Other data, such as transportation, processing, and transformation costs, are collected from American Crystal Sugar Company. Population and income data are collected from the U.S. Census Bureau.

Organization

The U.S. and world sugar programs, trade policies, production, and consumption are described in Chapter II. Chapter III provides a review of several previous studies performed on sugar trade. In Chapter IV, the spatial equilibrium model in determining sugar trade flows under an FTAA is discussed along with data collection. The Results of the study are described in Chapter V, and conclusions and recommendations are included in Chapter VI.

CHAPTER II

SUPPLEMENT UNITED STATES AND WORLD SUGAR INDUSTRY AND POLICY

U.S. Sugar Program and Trade Policy

The Food and Agricultural Act of 1981 established the loan-purchase program with domestic price supports utilized in current U.S. sugar policy (Marks and Maskus 1993). Several alterations have been made to the original program by the Food and Security Act of 1985; the Food, Agriculture, Conservation, and Trade Act of 1990; the Federal Agriculture Improvement and Reform (FAIR) act of 1996; and, most recently, the 2002 Farm Bill.

The FAIR act, effective for crop years 1996-2002, allowed the loan program, administered by the Commodity Credit Corporation (CCC), to provide fixed loan rates frozen at 1995 price levels of 18 cents for raw cane sugar and 22.9 cents for refined beet sugar, providing a price floor for sugar producers in the United States. The rates may not be raised by government legislation but can be decreased if other major sugar-producing countries negotiate reductions in domestic and export subsidies (FAS Online 1996). This loan program is reauthorized through fiscal year 2007 by the 2002 Farm Bill (Haley and Suarez 2002).

The sugar program allows sugar processors to use their sugar as collateral for U.S. Department of Agriculture (USDA) loans. This program allows processors to store sugar rather than sell at low market prices. The total loan length is up to nine months and must be repaid along with interest charges by September 30. Processors pay producers for delivered beets and cane, and final loan payments are made once the sugar is sold.

The type of loan a processor receives may either be recourse or nonrecourse. The loan type is dependent on the tariff-rate quota (TRQ) level. TRQs were established under the General Agreement on Tariffs and Trade (GATT) Uruguay Round Agreement (URA) when the United States assumed tariff-rate quotas for both raw and refined sugar imports (Skully 1998). If the TRQ is at or below 1.5 million short tons, a recourse loan exists, and a processor forfeits its sugar collateral to the CCC, regardless of price (FAS Online 2001). If the TRQ is above 1.5 million short tons, the loans are nonrecourse. If the market price is below the price floor, the processor will forfeit its collateral to the CCC. Previous marketing assessments and forfeiture penalties implied by the FAIR act are terminated by the 2002 Farm Bill.

Under the 2002 Farm Bill, the Secretary of Agriculture is commissioned to operate the sugar program without cost to the U.S. Treasury. Running a low-cost program is accomplished by avoiding sugar loan forfeitures in the nonrecourse loan program (Haley and Suarez 2002). Several features in the 2002 Farm Bill are intended to reduce these sugar forfeitures.

Payment-in-Kind (PIK): PIK payments offer sugar beet growers the option of not harvesting a specific number of planted beet acres in exchange for an amount of CCC inventory of sugar. PIK payments are limited to $20,000 per farmer. Bids are based with a per-acre cap on a specific producer's previous 3-year average sugar production. This program was utilized in August 2000 and 2001 when the CCC was faced with large sugar supply and low domestic prices (Haley and Suarez 2002).

Marketing Allotments: Marketing allotments may be assigned by the Secretary of Agriculture to sugar processors and cane producers to aid in balancing the domestic sugar market, acting as a sugar inventory control. These allotments are synchronized with import commitments under WTO standards and NAFTA. These allotments shift excess storage costs from the government to the sugar industry itself.

The Sugar Storage Facility Loan Program: The Sugar Storage Facility Loan Program makes financing available through the USDA for domestic beet or cane processors to construct or upgrade storage and handling facilities for their sugars. This loan program for storage improvement is conducive for orderly marketing of domestically produced sugar by processors and also eliminates a large burden for the government by taking on the sugar storage burden (Haley and Suarez 2002).

Reporting Requirements: Reporting requirements by the USDA are expanded to better track non-TRQ sugar, molasses, and syrup imports (Haley and Suarez 2002).

<u>Tariff Rate Quotas</u>

The United States operates under the tariff rate quota (TRQ) system since the URA-GATT liberalized much of the world's sugar policies. Neither the FAIR act of 1996 nor the 2002 Farm Bill changes the U.S. Harmonized Tariff Schedule. The Harmonized Tariff Schedule divides the tariffs paid into two tiers. The first-tier (in quota), low-duty tariff ranges from zero to 0.625 cents per pound, and must add to a minimum TRQ of 1.256 million short tons of both raw and refined sugar each marketing year. A refined allocation commitment of 24,250 short tons is included in the total commitment (Haley and Suarez 2002).

The second-tier (above quota) duties have been reduced under the URA in recent years. In 2000, the duty for raw can sugar was reduced to 15.36 cents per pound and the duty for refined sugar reduced to 16.21 cents per pound. Table 2.1 shows the raw sugar TRQ allocations for fiscal year 2001 taken from the USDA.

Forty countries receive a raw cane sugar TRQ, which is based on an unrestricted trade period of 1975-1981. The TRQ quantity is reallocated each year by the U.S. Secretary of Agriculture, using a formula calculated by the USDA. Table 2.1 illustrates the TRQ allocations for fiscal year 2001 in metric tons raw value.

Table 2.1. TRQ allocations fiscal year 2001, metric tons raw value

Country	TRQ Allocation
Raw Sugars	
Argentina	45,283
Australia	87,408
Barbados	7,372
Belize	11,584
Bolivia	8,425
Brazil	152,700
Colombia	25,274
Congo	7,258
Costa Rica	15,797
Cote d'Ivoire	7,258
Dominican Republic	185,346
Ecuador	11,584
El Salvador	27,381
Fiji	9,478
Gabon	7,258
Guatemala	50,549
Guyana	12,637
Haiti	7,258
Honduras	10,531
India	8,425
Jamaica	11,584
Madagascar	7,258
Malawi	10,531
Mauritius	12,637
Mexico[1]	7,258

Table 2.1. (Continued)

Country	TRQ Allocation
Mozambique	13,690
Nicaragua	22,115
Panama	30,540
Papua New Guinea	7,258
Paraguay	7,258
Peru	43,177
Philippines	142,169
South Africa	24,221
St. Kitts and Nevis	7,258
Swaziland	16,850
Taiwan	12,637
Thailand	14,743
Trinidad-Tobago	7,372
Uruguay	7,258
Zimbabwe	12,637
Subtotal raw cane sugar	1,117,195
Refined Sugars	
Mexico(NAFTA) [1]	105,788
Mexico (Sept. 1997, 1998, 1999, 2000, 2001, 2002 allocation)	2,954
Canada (Sept. 1997, 1998, 1999, 2000, 2001, 2002 allocation)	10,300
Specialty sugar [2]	17,656
Other refined sugars [2]	7,090
Subtotal refined sugars	143,788
Total TRQ for fiscal year 2002	1,389,997

[1] Under NAFTA, Mexico may ship either raw or refined.
[2] Specialty and other refined sugars are admitted under a first-come, first-served basis.
Source: USDA-ERS (2002).

<u>Sugar Trade Under NAFTA</u>

Under the North American Free Trade Agreement (NAFTA), the sugar trade with Mexico will become completely liberalized. NAFTA's Side Letter sugar provisions figure duty-free trade access amounts to a "net surplus producer" formula. The surplus is calculated by the difference between the sum of Mexican sugar and high fructose corn syrup (HFCS) consumption and the projected production of sugar (Haley, May 2000). The original duty-free sugar access was limited to the amount of net surplus, but not to exceed 25,000 metric tons raw value. However after October 1, 2000, the maximum duty-free amount was increased to 250,000 metric tons raw value. During the 15-year transition period, Mexico is subject to high-duty tariff rates (Low-duty rates are zero,) which steadily decrease until they also reach zero in 2008 (Salsgiver 1997). Table 2.2 reports the depreciation of high-tier tariffs for the rest of world (ROW) and Mexico.

Table 2.2. U.S. high-tier tariff schedules from ROW and Mexico, cents per pound

Year	Rest of World (ROW)		Mexico	
	Raw cane sugar	Refined sugar	Raw cane sugar	Refined sugar
Base	18.08	19.08	16.00	16.95
1995	17.62	18.60	15.20	16.11
1996	17.17	18.12	14.80	15.69
1997	16.72	17.65	14.40	15.26
1998	16.27	17.17	14.00	14.84
1999	15.82	16.69	13.60	14.42
2000	15.36	16.21	12.09	12.81
2001	15.36	16.21	10.58	11.21
2002	15.36	16.21	9.07	9.61
2003	15.36	16.21	7.56	8.01
2004	15.36	16.21	6.04	6.41
2005	15.36	16.21	4.53	4.81
2006	15.36	16.21	3.02	3.20
2007	15.36	16.21	1.51	1.60
2008	15.36	16.21	0.00	0.00

Source: Haley (1999).

<u>Re-Export Programs</u>

The United States also runs two sugar re-export programs that maintain competition for domestic refiners and manufacturers of sugar-containing products in world markets. Both the Sugar Re-Export Program and the Sugar-Containing Products

Re-Export Program allow the importation of duty-free sugar at world price for immediate export to the world market in either refined sugar form or within sugar-containing products (Haley and Suarez 2002).

World Sugar Trade Policy

The European Union (EU) and South Africa both hold high internal support prices and export subsides. The EU sugar program has internal support nearly 30% higher than the United States. The EU basic internal supports include import restrictions with limited free access for certain suppliers, internal price supports that guarantee producer returns for a fixed quantity of production and permit the maintenance of refining capacity, and export subsidies for a quantity of domestically produced sugar (Borremans 1999).

Australia, China, and India all use a form of state trading enterprises (STEs) to protect their domestic producers. STEs allow one appointed statutory authority to be responsible for the producers in the country. STEs support domestic producers in their nations through buyer-seller agreements, marketing quotas, dual pricing arrangements, and other quasi-government mechanisms. STEs were also not included in the Uruguay Round Agreement (URA), where many countries made agreements to reduce sugar subsidies which allow them to maintain a level of producer support significantly higher than other countries (Koo 2000).

The Mexican government recently announced a new sugar policy effective for the years 2002-2006. Previously, Mexico had utilized internal price supports and export subsidies similar to that of the EU and South Africa. The new policy is due to problems with several inefficient Mexican sugar mills expropriated by the Mexican government. The new Mexican sugar program will be more similar to an STE utilized by Australia, China, and India. It will involve no subsidies from the Mexican government, instead creating a sugar export cooperative association to manage all exports and to assign and monitor per-mill quotas induced for exports (Haley and Suarez 2002).

Sugar Production

United States Sugar Production

In fiscal year 2001, the United States produced 8,674,000 short tons raw value of sugar, consisting of both cane and beet sugar (USDA-ERS 2002). The major cane sugar producing areas include Florida, Louisiana, and Texas. The Red River Valley, Great Lakes, Upper Great Plains, and Far Western states make up the foremost sugar beet producing regions.

Table 2.3 summarizes the production of refined beet sugar in the four main U.S. production regions. Over 10 years, beet sugar production has increased overall by 26%. The Red River Valley shows the largest production increase of sugar at 76%. The Great Lakes and Upper Great Plains regions also increased their production by 10% each. The only region decreasing in sugar beet production area is the Far Western states by 2%.

Table 2.3. U.S. refined beet sugar production per region 1988-1990 and 1998-2000, and percent change in 1000 short tons

Region	1988-1990 Average	1998-2000 Average	% Change
Red River Valley	1,066	1,874	76
Great Lakes	381	419	10
Upper Great Plains	659	722	10
Far West	1,316	1,291	-2
Total	3,422	4,306	26

Source: USDA-ERS (Dec. 1996 and 2001).

Table 2.4 summarizes the U.S. refined cane sugar production over the same 3-year average as in Table 2.3. Cane sugar production trends are similar to that of beet sugar and experienced an overall increase of 18%. Louisiana shows the largest growth of 80% over the decade span. Florida and Texas increased sugar production by 35% and 3%, respectively. Hawaii experienced a large loss over the past 10 years by decreasing production by 61%.

Table 2.4. U.S. refined cane sugar production 1988-1990 and 1998-2000, and percent change in 1000 short tons

Region	1988-1990 Average Production	1998-2000 Average Production	% Change
Florida	1,396	1,879	35
Louisiana	739	1,330	80
Texas	88	91	3
Hawaii	863	335	-61
Total	3,086	3,635	18

Source: USDA-ERS (Dec. 1996, 2001).

World Sugar Production

A crucial factor for the United States in the event of an FTAA is the production capacity of South and Central American countries. In many of these countries, sugar industries provide important sources of income and economic stability. This industry dependence has caused investment in individual sugar industries, increasing production in many of the South and Central American countries (Suarez 1996). Table 2.5 compares selected countries' sugar production growth using a 3-year average production from fiscal years 1988-1990 and 1998-2000 (USDA-ERS 1990, 2001).

Table 2.5. World sugar production for selected countries 1988-1990 and 1998-2000, and percent change, 1000 short tons raw value

Country	1988-1990 Average	1998-2000 Average	% Change
United States	6,872	8,477	23
Mexico	3,851	5,676	47
Cuba	8,449	4,224	-50
Argentina	1,223	1,929	58
Brazil	9,014	19,872	120
European Union	16,239	20,817	28
Former Soviet Union	10,296	4,331	-58
South Africa	2,502	2,958	18
Australia	4,040	5,881	45
China	2,491	9,229	73
India	11,229	19,192	71
Thailand	3,805	5,639	48

Source: USDA-ERS (1990, 2001).

Brazil has emerged as one of the world's leaders in sugar production and exports. In the 1998/99 growing season, Brazil produced a record 320 million metric tons (MMT) of sugarcane, driving world sugar prices lower than 5 cents per pound (Bolling and Suarez 2001). Roughly half of Brazil's sugar cane stays within its borders for ethanol production. If prices of petroleum rise, ethanol will be even more important for Brazil's industry. Brazil is likely to remain a large market player in the sugar industry as it deregulates its industry, modernizes its ports, and reduces transportation costs from the mill to port (Bolling and Suarez 2001).

Other Central American countries such as Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Belize, and Panama also have great capacity for sugar production and exports. The sugar industry has been a means of improving trade and a higher standard of living for the people of these countries, leading to expansion of the industry. The sugar production and exports from these countries have both risen over 100% from 1979/80 through the 1995/96 growing season (Suarez 1996). The main export market for this sugar has been the United States. A regional free trade agreement will likely increase the amounts of imports even more.

Mexico's 47% increase in sugar production from 1990 to 2000 will largely affect the United States over the next several years as NAFTA liberalizes this sugar trade. This exceptional industry growth is due to technological adaptations in Mexican sugar mills, increasing their profitability (Haley, May 2000). A factor that may play a role in Mexican sugar exports to the United States will be substitution ability of U.S. high fructose corn syrup (HFCS) for sugar. If Mexican soft-drink makers begin using United States exported HFCS in their beverages rather than sugar, Mexico will have even more sugar on hand to export to the United States. The effects of these export increases would place more downward pressure on the U.S. domestic price with additional sugar on the market.

Comparison of Production Costs

In a regional free trade environment over the Americas, the key to sugar trade flows is to be the low-cost producer. The United States is a relatively a high-cost sugar producer compared to South and Central American countries (Haley 2002). Table 2.6 shows Western hemispheric production costs of raw cane sugar through the years of 1994/95-1998/99 in cents per pound.

The first two cost groupings produce over 80% of the total sugar cane sugar in the Western Hemisphere (Haley 2002). Considering all the U.S. cane production regions are in the upper cost categories, it indicates nearly all the Western Hemisphere's cane sugar production take places in areas other than the United States.

Table 2.6. Western Hemisphere cane sugar production costs, cents per pound

Group Category	Low	High	Average
Low Cost [1]	6.72	11.69	7.70
Low-to Medium Cost [2]	10.58	17.40	12.34
Medium-to-High Cost [3]	14.25	21.83	16.54
High Cost [4]	17.74	40.21	23.56

[1] Low-Cost group is comprised of Brazil-Center/South, Colombia, El Salvador, and Guatemala.
[2] Low-to-Medium Cost group is comprised of Bolivia, Brazil-North/East, Costa Rica, Ecuador, Mexico-Gulf and Pacific Coasts, Nicaragua, and United States-Florida.
[3] Medium-to-High Cost group is comprised of Argentina, Belize, Guyana, Honduras, Panama, Paraguay, Peru, United States-Louisiana and Texas.
[4] High-Cost group is comprised of Barbados, Dominican Republic, Jamaica, St. Kitts, Trinidad, United States-Hawaii, Uruguay, and Venezuela.
Source: Haley (2002).

The United States is the only significant producer of beet sugar in the Western Hemisphere and ranks as one of the lowest cost beet-sugar producers in the world (Haley 2002). However, the production costs are still high compared to its southern competitors, as shown in Table 2.7.

Table 2.7. U.S. cane and beet sugar production costs, cents per pound

Category	Low	High	Average
Cane sugar, white value equivalent	14.91	27.88	21.40
Beet sugar, eastern U.S.[1]	15.27	25.13	20.20
Beet sugar, western U.S.[2]	19.25	34.06	26.66

[1] Eastern beet sugar region comprised of Ohio and Michigan.
[2] Western beet sugar region comprised of California, Idaho, Oregon, Colorado, Minnesota, Montana, North Dakota, Nebraska, New Mexico, Texas, and Wyoming.
Source: Haley (2002).

The Western Hemisphere is a net surplus producer, at over 8.4 million metric tons. However, North America runs a deficit in sugar production, as the United States and Canada's shortfall overcomes Mexico's surplus by 2.0 million metric tons. The remaining country regions all run a high ratio of net surplus production to production: 57.1% in Central America, 36.2% in South America, and 32.9% in the Caribbean (Haley 2002).

Large surpluses joined with low costs of production in Central and South America indicate a high ability to aim sugar exports to the United States. The Caribbean area is fairly high-cost, creating uncertainty of additional sugar exports under a potential FTAA. Much of these sugar exports go the EU and the U.S. under prearranged agreements, which allow a higher price than world sugar price (Haley 2002).

Sugar Consumption

U.S. Domestic Consumption

Consumption of sugar and high fructose corn syrup (HFCS) in the United States has steadily risen over the 1985-1999 period (Sheales et al. 1999). Higher domestic sugar prices in the United States have given HFCS producers a competitive advantage in products in which the two sweeteners are close substitutes, as seen in the beverage industry. Roughly 70% of United States sugar consumption comes from the industrial sector, with roughly two-thirds going towards baker, cereal, and confectionery manufacturers (Sheales et al. 1999). Figure 2.1 shows these historical food uses for sugar over the past decade.

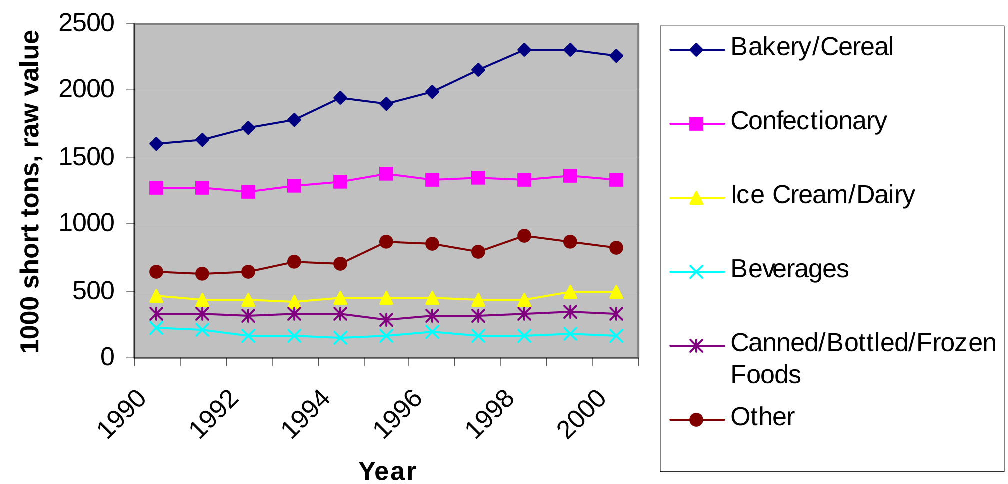

Figure 2.1. Sugar deliveries for human consumption 1990-2000.
Source: USDA-ERS (May 2001).

Per capita sugar consumption has risen nearly 10% over the past decade from 62 to 68 pounds (USDA-ERS May 1990 and May 2001). Table 2.8 divides U.S. sugar consumption into 12 regions, denoted by city per region acting as a sugar distribution center.

<u>World Sugar Consumption</u>

Sugar consumption has increased in most large producing countries over the past 10 years. Consumption is a large factor in determining trade flows among nations. Those countries with excess sugar have greater ability to export, changing sugar market conditions around the world. Table 2.9 shows changes in domestic consumption within selected countries spanning 10 years from the late 1980s to the late 1990s.

Table 2.8. United States sugar consumption in tons per region

Region	States Included	Population	Total Consumption Per Region (tons)
Northeast-New York City	CT, DE, District of Columbia, MA, MD, MS, NH, NJ, NY, PA, RI, VT	60,548,341	2,058,644
Southeast-Atlanta	GA, NC, SC, VA, WV	29,622,844	1,007,177
South-Miami	FL	16,396,515	557,482
South-New Orleans	AL, LA, MS, TN	17,527,836	595,946
South Central-Houston	TX, OK, AK	27,477,205	934,225
Midwest-St. Louis	IA, MO, KS, NB	12,960,762	440,666
Central East-Chicago	MI, IL, ID, OH, KT	44,026,960	1,496,917
Northwest-Billings	MT, ID, WY	2,719,862	92,475
North Central-Minneapolis	WI, MN, ND, SD	11,765,248	400,018
Northwest-Seattle	AK, WA, OR	10,095,732	343,255
Southwest-Denver	CO, UT, NM, AZ	13,823,980	470,015
West-San Francisco	CA, NV, HI	37,831,602	1,286,274
Total		284,796,887	9,683,094

Source: Total consumption: USDA-ERS (2001).
Population data: U.S. Census Bureau (2002).

Advances in technology and liberalized trade have allowed for larger sugar supply at lesser costs, increasing consumption in many nations. Mexico's fall in consumption reflects greater switching to high fructose corn syrup, exported from the United States through NAFTA, in food products. Other negative changes may represent other changes in consumer preferences.

Table 2.9. Per capita domestic consumption trends in pounds of sugar for selected countries 1988-1990 and 1998-2000, and percent change

Country	1988-1990	1998-2000	% Change
U.S.(including Puerto Rico)	62	68	9
Mexico	98	93	-5
Cuba	154	128	-17
Argentina	61	88	44
Brazil	93	110	18
European Union	69	78	14
South Africa	79	68	-14
Australia	103	109	6
China	14	15	5
India	27	36	31
Thailand	34	61	79
Philippines	45	51	13

Source: USDA-ERS (1990, 2001).
Population data: United States Census Bureau (2002).

CHAPTER III. LITERATURE REVIEW

The main areas of research in this Literature Review are trade relationships, liberalization policies, the United States sugar program, and future sugar price projections.

Related Trade Liberalization Studies

Free Trade Area of the Americas Research

The need for extended research on a possible Free Trade Area of the Americas (FTAA) is evident due to a lack of other empirical studies on this specific trade agreement. Haley (2002) studies implications of an FTAA on U.S. sugar supply, use, and prices by utilizing the USDA sugar baseline projections model. The status of individual countries' net surplus production is used to determine sugar trade flows from foreign countries. The foundation of U.S. policies and trade, including WTO and NAFTA obligations, the U.S. sugar non-recourse loan program, and other legislative programs, are honored to configure results under several alternative importing scenarios.

Haley's (2002) results find that threats to U.S. domestic sugar production intensify with increased liberalization of the U.S. sugar program and TRQ system combined with larger import levels. The complete liberalization of all programs and import quotas ultimately results in the U.S. domestic sugar industry's end. While the study finds general effects on the U.S. domestic industry, it does not evaluate individual regional production effects under different scenarios. The results of a study pertaining to each individual sugar production region will be more effective when negotiating the type of trade commitment the United States will make regarding sugar when forming an FTAA.

Uruguay Round Agreement (URA)-General Agreement on Tariffs and Trade (GATT)

To examine the possible effects of an FTAA, studies on previous trade agreements aid in examining trade flows. The Uruguay Round Agreement (URA) of the General Agreement on Tariffs and Trade (GATT) policy change in national sugar programs was a large step in liberalizing world sugar trade. Devados and Kropf (1996) evaluate the effects of the URA using a non-spatial equilibrium world sugar model. The model determines the effects of domestic and trade policy changes under the URA on production, stocks, and trade. The price linkage equation measures the wedge driven between domestic sugar price and world price, measuring the effects of the URA liberalization. The study finds countries with large policy changes induced by the URA have larger increases in consumption due to lower domestic prices. No distinct changes in sugar supply are expected because policy changes detailed in the URA have already been implemented over the past 10 years in most participating countries. However, the study does indicate that high-cost producers are expected to produce slightly less and that low-cost producers are expected to increase production and export more under the liberalized trade programs.

NAFTA and Mexican Impact Studies

Through the North American Free Trade Agreement (NAFTA), Mexico will be allowed complete free access to the U.S. sugar market. Several studies have evaluated the impacts of Mexican sugar exports on the U.S. domestic industry.

Devadoss et al. (1995) examine the trade creation and diversion effects derived from NAFTA on United States imports from Mexico. The study utilizes a 21-country nonspatial world sugar model incorporating NAFTA provisions to quantify these trade flows. The study predicts Mexico to increase sugar production 11.4% per year over the baseline projections, citing increased technology and investments, and lower wages to gain the country net sugar exporter status. Through years 2000-2004, Mexico is expected to increase its exports due to technology exported from the United States through NAFTA. The study shows increased imports by the United States under these liberalization provisions will begin to replace United States domestic production. United States imports will also be diverted from other countries toward Mexico in 2008, once NAFTA fully liberalizes this sugar trade.

Koo and Taylor (1995) analyze the impacts of NAFTA and GATT on the North American sugar industry. The study examines United States regional production competitiveness using a spatial equilibrium model. The study reports that relaxing the sugar import quota by 20%, 50%, and 100% would have larger impacts on cane production than the beet, but shows decreased net revenue for the sugar industry as a whole in all scenarios. However, elimination of sugar programs would completely replace the domestic industry with imports. The study relates that the Red River Valley and Northwest Regions would have greatest chance to survive in the event of a liberalized sugar program and trade.

Heboyan et al. (2001) examine the NAFTA effects of Mexico's imports on the United States domestic industry using the multi-region, open economy Global Trade Analysis Project (GTAP) model. The study predicts that U.S. sugar producers will lose

$7.5 million in surplus as their market share falls with the domestic price from increased sugar imports. United States consumers and sugar processors will gain lower sugar prices, an amount of $8.5 million in gained surplus, from the agreement. Mexican producers will gain from receiving the higher U.S. price; however, Mexican consumers will lose from the higher prices and lower domestic supply. The study also suggests the U.S. government will have to support U.S. domestic producers in accordance with the domestic sugar program in the amount of $29.2 million.

European Union Studies

As a large sugar exporter and high producer subsidy holder, the European Union's (EU) liberalization of its sugar policies would have a large impact on world trade. The EU's sugar policy holds a large distorting effect on the world price of sugar. This connection to the world sugar price has great possibility of affecting the United States sugar industry if an FTAA is implemented.

Leuck and Neff (1991) use an econometric model to determine the outcome of several scenarios involving reform in the EU sugar program. Because the EU's production quota system does not allow excess amounts of sugar to be transferred among producers and is not protected by a price support, any excesses are transferred to the world sugar market. This program promotes an inefficient production system compared to what the program might be if there were transferable quotas or no quota system at all. The simulations use market supply functions that cannot be directly estimated, due to how the current quota program distorts the supply response of producers. Parameters of this synthetic model's functions are econometrically estimated previous supply elasticities, cost of production, and distorted program supply functions.

The EU may work to reduce trade distortions through quota transfer restrictions or elimination of the entire quota program. The study finds that, if transfer quotas are allowed, both within country and over national borders, net exports fall from the base of 3.8 million metric tons (MMT) to 1.5 MMT, raising world prices by 8%. When trading quotas are limited within their own countries, net exports fall even more from the base case to 0.1 MMT, and world prices increase by 13%. A program elimination would make all sugar produced in the EU at world prices, causing the EU to become a net importer of sugar, increasing world price by 16% (Leuck and Neff 1991).

Poonyth et al. (2000) expand the study performed by Devadoss and Kropf (1996), adding the implications of the current World Trade Organization agreement on the EU sector by disaggregating the EU community into individual member countries. A nonspatial partial equilibrium model is used, and demand, supply, and price determination are determined through econometric analysis. The study finds that the impact on the world sugar market is dependent on the level of subsidized EU sugar export reduction. If a WTO liberalization agreement does not require reduced tariffs but does reduce subsidized exports, the EU may reduce its quotas to meet its reduction obligations. This strategy does not aid any other sugar exporting countries because the EU still has a large level of internal market distortion. However, if a WTO agreement did require large tariff reductions, the EU would be forced to reduce price supports to avoid large imports of sugar. Even if the EU is not forced to increase sugar imports, the reduction of its exports will be enough to assist other sugar exporters and also the EU sugar consumer (Poonyth et al. 2000).

Koo (2000) used a global sugar simulation model (Benirschka et al. 1996) to examine price, production, consumption, and imports under free trade situations. The study predicts that, if free trade areas exist and the United States and European Union (EU) both eliminate domestic sugar programs and liberalize trade policies, the United States would remain competitive in the sugar market. However, Koo finds, if only the United States eliminates its import restrictions and sugar programs, the domestic industry would suffer. If the Cuban trade embargo continues and other countries maintain their sugar programs, where the U.S. eliminates its sugar program, the U.S. wholesale price decreases 28% because of increased imports. The research suggests that the U.S. sugar industry would subsist if both the United States and EU participate in trade liberalization policies and drop sugar programs.

Koo also finds that the Red River Valley, the most competitive sugar beet producing area in the United States, will continue operating due to low production and processing costs. If market price falls below 16.75 cents, all sugar-producing regions in the United States, including the Red River Valley, will be failing (Koo 2000).

U.S. Sugar Program and Trade Policy

The current U.S. sugar program may prove to augment negative effects of a potential FTAA. The U.S. sugar program has been viewed as a highly protective policy for domestic producers. If trade is liberalized with South and Central American countries, the amount of sugar imported to the United States will increase, which will place a strain on the domestic price and, in turn, the nonrecourse loan program. Several studies have been performed regarding the U.S. sugar program and how it affects trade flows, prices, and costs to consumers. In the event of an FTAA, the sugar program will play a key role in the U.S. domestic industry survival.

U.S. Sugar Program

Robertson et al. (2000) analyze the costs and benefits of the U.S. sugar program for a United States General Accounting Office (GAO) Congressional Report. A nonspatial, partial equilibrium econometric world sugar model (the CARD International Sugar Model) incorporates 29 countries/regions of the world's largest sugar producing, exporting, and importing countries. The study defines sweetener users as sugarcane refiners, food manufacturers, and final consumers of sweeteners or sweetened products. They estimate the total costs to domestic sugar users from the current program at $1.9 billion in 1998, up from $1.5 billion in 1996. This number is derived in relation to world price. When the world sugar price falls, the United States sugar domestic price support maintains producer price received, and higher costs result for domestic sweetener users. U.S. domestic sugar producers receive large benefits from the current program, $800 million in 1996 and $1 billion in 1998. Monetary benefit from the program is split by 70% toward beet and 30% toward cane producers (Robertson et al. 2000).

The study claims that the current sugar program promotes economic inefficiencies and includes high support prices, encouraging U.S. sugar beet farmers to plant beets rather than another crop and causing artificially high sugar prices that deter consumers from purchasing domestic sugar. The GAO states that larger benefits to consumers would result if the current U.S. sugar program was dropped. This study does not incorporate the effects of the NAFTA reduction of the TRQ with Mexico through 2008. Additional sugar supply due to imports from South and Central America under an FTAA will also influence the costs and benefits of the sugar program and need further evaluation (Robertson et al. 1999).

In another study performed by the GAO, Robertson et al. (1999) suggest that the USDA uses the TRQ system to inflate the U.S. domestic price, by restricting low-cost foreign imports, in order to avoid forfeitures to the Commodity Credit Corporation (CCC). In the current system, the USDA compares domestic sugar producers' year-end stocks with the projected sugar consumption, known as the stocks-to-use ratio. A small stocks-to-use ratio indicates tighter supplies, a lower TRQ, and a higher domestic price while a large ratio is linked to a large sugar supply, larger TRQ, and lower domestic prices. The GAO suggests this method is costly for consumers and recommends that the TRQ is gradually increased to lower the domestic price. The GAO suggests that the TRQ system should be altered by reallocating unfulfilled quota shares by exporting countries or form an entirely new basis for the TRQ allocation process.

Haley (1999) provides a counterargument for this criticism by the GAO on the current U.S. sugar program. He analyzes refined sugar pricing relationships with the stocks-to-use ratio through econometric analysis, and finds refined sugarbeet prices and the ending stocks-to-use ratio are not directly related. An even weaker correlation between refined beet sugar spot price and beet sugar producer price was found after further econometric analysis. This weak price correlation indicates the best way to predict the following quarter's beet price is from the previous quarter's price. The study concludes that weak relationships among sugar stocks, end uses, and refined sugar prices signify that setting a “higher-than-necessary” raw sugar price is a reasonable policy goal, given lack of power of the TRQ to directly change the pricing of refined sugar (Haley 1999).

A 2001 study by Haley claims the current U.S. sugar program loan rate system would not be feasible if liberalization occurred at WTO minimum import levels. The USDA sugar baseline projection, based on macroeconomics, agricultural policy, weather, and international developments, is used in this forecasting, the results of a 50% increase in minimum WTO sugar imports. The results predict that, for prevention of CCC forfeitures, a sustainable loan rate would be 4 cents lower than the current loan rate of 18 cents per pound for raw sugar, at 14 cents per pound. The study also suggests the current TRQ allocation would have to be adjusted by removing provisions for countries where the price margins between the world and U.S. sugar price are not wide enough to make exports viable. Allocations of U.S. sugar imports would be shifted to low-cost producers such as Australia, Brazil, and Mexico (Haley 2001).

Suggestions for U.S. Sugar Policy and Trade Reform

Many alternatives have been suggested for revisions of the United States sugar policy and trade program. Skully (1998) studies the possibility of auctioning tariff quotas for U.S. sugar imports rather than the current system where the quotas are allocated diplomatically. Auctioning tariff quotas would likely change the market shares of U.S. sugar importers because the low-cost producers would be able to bid more for tariff quota rights. The United States would raise extra revenue equal to the difference between domestic and world price times the amount of tariff-rate quota auctioned. The study hypothesizes that, in 1997, Brazil, the Philippines, Australia, Argentina, Peru, Panama, and several other quota exempt Central American countries could have provided 76.9% of all U.S. sugar imports (Skully 1998). Due to Skully's indication that Central and South American sugar producers could maintain nearly all of the U.S. TRQs under the proposed auction system, potential FTAA trade flows with these countries would increase U.S. sugar imports immensely.

Knepper et al. (2001) discuss the strain on the U.S. sugar policy from increasing imports under liberalized trade, indicating that increased forfeitures to the CCC are very possible. The examination provides several methods of solving the problem with the U.S. sugar program. One suggestion is to maintain existing import levels by increasing the quotas of Mexico and Canada, and decreasing quotas for others. Another is to reduce the loan rate (price floor) to be more even with import commitments. They suggest that the current nonrecourse loan program loan could be replaced with a marketing loan used for other types of agricultural commodities. The discussion proposes that the government maintain tighter controls on U.S. domestic production to eliminate forfeitures, or finally, some sort of sugar buy-out program could be implemented. A buy-out program may allow producers to bid for a lump-sum payment to exit the market, or the government could pay a lump-sum payment to every producer for loss compensation at the sugar program's elimination (Knepper et al. 2001).

Sugar Production and Price Projection

Production and price forecasting studies offer insight to future trends in the world sugar market. The following studies deal with sugar production and price forecasting under current situations, including NAFTA provisions.

NAFTA has altered how the U.S. sugar market will react with respect to prices and consumption. Haley (January 2000) uses supply and demand analysis to discuss how the USDA has incorporated price-sensitive Mexican imports, which are the high-tier tariff imports through 2007 and the following unrestricted duty-free imports, to determine the U.S. sugar baseline projections for the coming growing season. With large future production and export potential, the U.S. sugar price is predicted to fall. This characteristic is needed in the U.S. baseline to capture a more realistic view of the domestic market. The importance of Mexican imports in the baseline is even more important due to record increases in U.S. production levels and the Uruguay Round imposed combined minimum level of the raw and refined sugar TRQs (Haley, January 2000).

Koo and Taylor (2001) predict sugar market prices for the time period 2000-2010 using the Global Sugar Policy Simulation Model (Benirschka et al. 1996). Econometric techniques and time series data are used to discover production, consumption, and carry-over stocks. The study assumes no changes in farm and trade policies by sugar exporting and importing countries for the year 2001. World price is expected to increase roughly 4 cents to 12.67 cents in 2010 and world sugar trade to increase by 4.6%. With the exception of Brazil and Thailand, where sugar consumption is expected to increase faster than production, sugar trade is projected to increase. The study also reveals that the U.S. domestic price is expected to reach its lowest at 23 cents in 2001, and rise marginally to 25 cents in 2002 and 26.6 cents in 2010. These prices reflect increased exports due to increased Mexican imports under NAFTA levels. U.S. imports are expected to rise to 23% of domestic consumption.

Mexican production and exports are predicted to increase 44.5% due to conditions under NAFTA (Koo and Taylor 2001).

Summary of Literature Review

The goal of this thesis is to determine the optimal quantity of sugar traded under a Free Trade Area of the Americas agreement. Alternative combinations of trade policy and domestic programs discussed in these studies will contribute to the total effects of an FTAA on the U.S. sugar industry. Individual effects on each U.S. producing region have typically been overlooked in previous research examining trade agreement effects on the industry.

Past research on the sugar industry has the same conclusion: increased imports imposed by liberalized trade agreements place downward pressure on the U.S. domestic price. Studies show that the U.S. sugar program will face great strain from large amounts of sugar stocks from the liberalizations, due to the price floor imposed by the sugar loan rate. Previous research suggests the falling domestic price will have harmful effects on individual producers once sugar imports rise and domestic prices fall to certain levels. Projection studies have accounted for NAFTA and other WTO-imposed quota and tariff relaxing measures, but none have considered impacts of increased FTAA imports.

Studies modeling the effects of the highly distorting European Union (EU) are included in the Literature Review as an example of domestic trade policy distorting world trade flows. Under the event that the EU would drop its sugar program, world sugar trade flows may shift drastically, which may be an indication of what might happen if the United States followed suit. However, elimination of sugar programs is unlikely to occur in the near future. Because of this, the EU effects are not included in the model, nor are effects of the U.S. elimination of the domestic sugar program.

This thesis attempts to combine NAFTA and WTO regulations with the current U.S. sugar policy to calculate the total effects of alternative tariff and quota scenarios that may result under an FTAA. It also examines the domestic price effects on each U.S. sugar production area to figure how competitive each aspect of the domestic industry will be under larger import quotas.

CHAPTER IV. METHODOLOGY

This chapter describes the development of the multinational/regional trade model used in the study. Methods, equations, notation, data, and baseline and counterfactual scenarios evaluated in the study are discussed.

Method

The model developed for this study is a spatial equilibrium model based on a quadratic programming algorithm. The model's goal is to determine the optimal quantity of sugar traded under an FTAA by maximizing social welfare across all countries within the model. Maximizing social welfare is accomplished by maximizing the sum of U.S. consumer surplus of refined sugar per region; U.S. producer surpluses of both raw and refined sugar; and foreign producer surpluses from both raw and refined sugar less handling, transportation, and processing costs. Figure 4.1 contains the graphical framework explaining how the optimal sugar quantity traded is modeled under FTAA conditions.

The demand curve in Figure 4.1 represents the United States consumer demand for refined sugar. The top line supply line, S_{US}, represents United States domestic supply of refined sugar. Foreign sugar imports are represented by the wedge between S_{US} and the dotted supply line, S_W, which represents total United States sugar production plus foreign imports. Surplus areas are denoted as *CS*, *PS*, and *FPS* for consumer surplus, U.S. producer surplus, and foreign producer surplus, respectively.

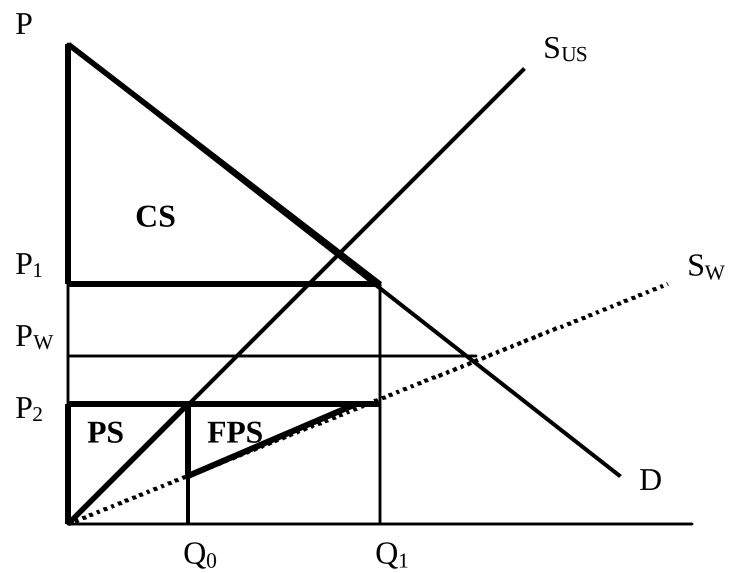

Figure 4.1. Graphical representation of the methodology utilized in the model.

When the United States imports sugar from foreign countries, the equilibrium sugar quantity changes from Q_0 to Q_1. Another result from sugar importation is a price wedge driven between price paid by consumers, P_1, and the price received by producers, P_2. This wedge is due to transportation, handling, and processing costs along with tariffs and quotas. Rents captured by sugar refineries by importing non-tariff sugar also contribute to this price wedge. By maximizing the sum of surplus areas, optimal sugar quantities traded can be found.

The model allows United States refined consumers to receive refined sugar from two sources: U.S. sugar beet processing facilities and raw cane sugar refineries. The transportation costs charged in the model are incurred by a combination of ship and rail. Processor rents, handling, processing, and tariff charges are also included. The modeling of sugar trade flows and various costs to reach the final United States refined sugar consumer are outlined in Figure 4.2.

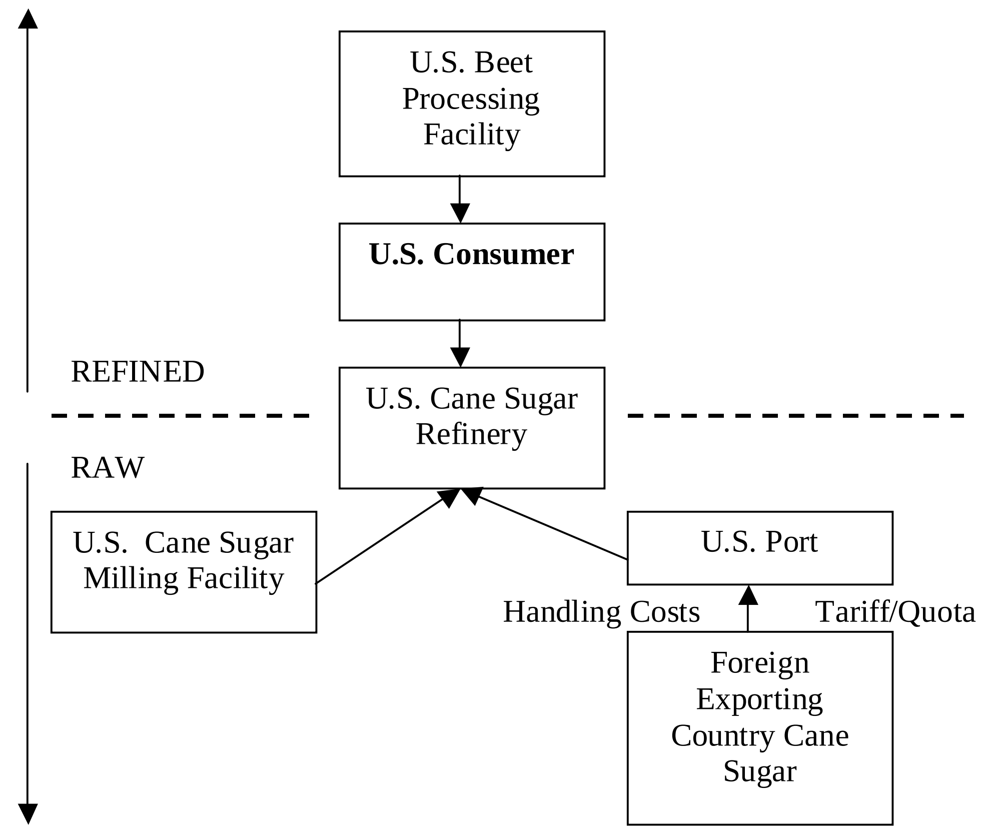

Figure 4.2. Modeled sugar flows and incurred costs.

U.S. imports of raw cane sugar are subject to transportation costs, port handling costs, and tariffs imposed. Additional transportation costs are gained from that port to a U.S. refinery and from the refinery to consumers. The model also includes processing costs charged at cane sugar refineries and processor rents captured from importing foreign sugar. Refined sugar imports are not included in the model, as they are a small percentage of total imports.

<u>Notation</u>

The notation for the mathematical programming model is described in Table 4.1.

Table 4.1. Definition of model variables and selected parameter values

Notation	Definition
h	Variable subscript indicates U.S. cane refinery *h*
I	Variable subscript indicates U.S. consuming region *i*
j	Variable subscript indicates U.S. producing region *j*
m	Variable subscript indicates foreign sugar exporting country *m*
P	Variable subscript indicates U.S. port *p*
D_i	Demand for sugar in U.S. consuming region *i*
Q_i	Refined sugar quantity in U.S. consuming region *i*
S_j	Supply of sugar in U.S. producing region *j*
Q_j	Refined sugar quantity in U.S. producing region *j*
S_m	Supply of sugar in foreign exporting country *m*
Q_m	Refined sugar quantity in foreign exporting country *m*
P_{US}^{REF}	U.S. wholesale refined beet sugar price, 1998-2000 average= *$0.0984 cents per pound*
P_{world}^{RAW}	World refined sugar price, 1998-2000 average= *$0.2486 cents per pound*
a_i	Intercept term of region U.S. consumer demand function
b_i	Price responsiveness coefficient in U.S. consumer demand function
d_j	Intercept of the U.S. refined sugar supply equation
e_j	Price responsiveness coefficient of the U.S. refined sugar supply function
d_m	Intercept of foreign exporting country refined sugar supply function
e_m	Slope of foreign exporting country refined sugar supply function
t_{ji}	Transportation costs from U.S. producing region *j* to U.S. consuming region *i*
t_{mp}	Ocean transportation costs for raw sugar from foreign country *m* to U.S. port *p*
t_{ph}	Rail transportation costs for raw sugar from U.S. port *p* to U.S. cane refinery *h*
t_{jh}	Rail transportation costs for raw sugar from U.S. sugar producing region *j* to U.S. refinery *h*
t_{hi}	Rail transportation costs for refined sugar from U.S. refinery *h* to U.S. consuming region *i*
PC_h	Processing costs incurred at sugar refinery *h*
Q_i^D	Total refined sugar demand across all U.S. consuming regions, *i*
Q_j^S	Total supply of refined sugar from all U.S. producing regions, *j*
Q_m^S	Total supply of refined sugar across all foreign exporting countries, *m*
R_j^S	Total supply of raw sugar across all U.S. producing regions, *j*
R_m^S	Total supply of raw sugar across all foreign exporting countries, *m*
q_{ji}^s	Refined sugar flows from beet producing region *j* to consuming region, *i*

Table 4.1. (Continued)

r^{s}_{jhi}	Sugar flows from cane producing region *j* to *h* to *i*
r^{s}_{mphi}	Sugar flows from cane producing country *m* to port *p* to refinery *h* to consuming region *i*, and may be either *“no-tariff”* or *“tariff”*
α	Transformation rate from raw to refined in refineries, *h= 1.07*
handle(p)	Cargo handling costs incurred at each port, *p*, by country *m*
pwedge	Price wedge driven between U.S. and world price due to extra revenue gained by refineries on within-quota non-tariff imported sugar
tariff	2001 over quota, high-duty raw tariff for all countries= $0.1536 cents per pound
	2001 over quota, high-duty raw tariff for Mexico under NAFTA provisions= *$0.01058 cents per pound*
$quota_m$	2001 quotas for countries in U.S. TRQ schedule, as listed in Table 2.1.
$melt_h$	Annual melting capacities for U.S. sugar refineries, as listed in Table 4.3.

Sugar Demand Data and Equations

The model is built with several supply and demand equations as its base. The consumer demand function, for U.S. consuming region *i*, regarding refined sugar is given as

(1) $$D_i(Q_i) = a_i + b_i P_{US}^{REF} \quad ,$$

where demand is a function of total quantity of sugar consumed, both domestic and imported. P_{US}^{REF}, the wholesale refined beet sugar price, and parameters a_i and b_i represent the intercept of the demand function and price responsiveness coefficient, respectively. This equation is calculated using an elasticity taken from Benirschka et al. (1996) and computed at an average U.S. domestic per capita income of $28,000. Demand parameters utilized in the model are shown in Table 4.2.

Table 4.2. Demand equation parameters

U.S. Consuming Region	Total Sugar Consumption (1000 tons)	U.S. Demand Elasticity	Intercept (a)	Slope (b)
NE-New York	2047.385	-0.39	2845.865	-0.001606
SE-Atlanta	1001.668	-0.39	1392.319	-0.000786
S-Miami	554.433	-0.39	770.661	-0.000435
S-New Orleans	592.687	-0.39	823.835	-0.000465
SC-Houston	929.116	-0.39	1291.471	-0.000729
C-St. Louis	438.256	-0.39	609.176	-0.000344
C-Chicago	1488.730	-0.39	2069.335	-0.001168
NC-Minneapolis	397.831	-0.39	552.985	-0.000312
NC-Billings	91.970	-0.39	127.838	-0.000072
NW-Seattle	341.378	-0.39	474.515	-0.000268
SW-Denver	467.445	-0.39	649.748	-0.000367
SW-San Francisco	1279.240	-0.39	1778.143	-0.001003

Per capita sugar consumption is determined by dividing the total average U.S. domestic consumption by the average U.S. population for years 1998-2000. The U.S. per capita sugar consumption is calculated to be 68 pounds. Total demand for sugar per region is determined by multiplying the calculated U.S. per capita consumption times the consuming region's population. Consumption data are taken from several United States Department of Agriculture (USDA) *Sugar and Sweetener: Situation and Outlook* reports (USDA-ERS 2001), and population data are taken from the U.S. Census Bureau (2002). Each consuming region is described based on cities that are sugar distribution centers across the United States.

Sugar Supply Data and Equations

Sugar production, export, and import data are collected from various USDA *Sugar and Sweetener: Situation and Outlook* (USDA-ERS 2001) reports. All data used in the model are three-year averages from fiscal years 1998, 1999, and 2000. A total of 10 international regions are included in the model encompassing 26 countries plus 7

U.S. producing regions. Countries and regions chosen for the model are those holding the greatest potential effects on the U.S. domestic industry in the event of an FTAA, which are TRQ-holding countries in South and Central America. Other sugar countries/regions included are the United States, Mexico, the Caribbean, Australia, the Philippines, and South Africa. Table 4.3 describes the countries and states included in each region utilized by the model.

Table 4.3. Exporting countries/regions within country set and U.S. producing region

Country/State	Region
Brazil, Guyana	SA Region 1
Argentina, Uruguay, Paraguay	SA Region 2
Bolivia, Peru, Ecuador, Colombia	SA Region 3
Costa Rica, Panama, Nicaragua, Honduras	CA Region 1
El Salvador, Belize, Guatemala	CA Region 2
Mexico	Mexico
Barbados, Dominican Republic, Haiti, Jamaica, St. Kitts and Nevis, Trinidad-Tobago	Caribbean
Australia	Australia
Philippines	Philippines
South Africa	South Africa
Minnesota, North Dakota	Red River Valley
Michigan, Ohio	Great Lakes
Montana, Colorado, Idaho	Upper Great Plains
California	Far West
Florida	Florida
Louisiana	Louisiana
Texas	Texas

Raw sugar data are converted to refined equivalent for supply function estimation. Each U.S. sugar supply equation is calculated on the average U.S. wholesale beet sugar price. U.S. producing regions', j, supply function for refined sugar is given as

(2) $$S_j(Q_j) = d_j + e_j P_{US}^{REF}.$$

Elasticities vary for beet and cane sugar production in the United States. Some elasticities are estimated with data from USDA *Sugar and Sweetener: Situation and Outlook* (USDA-ERS 2001). Others are taken from Benirschka et al. (1996). Table 4.4 shows parameters utilized in supply equation estimation.

Table 4.4. U.S. supply equation parameters

Region	Refined (Beet) Elasticity	Raw (Cane) Elasticity	Refined Calibrated Production (1000 tons)	Intercept (d)	Slope (e)
Red River Valley	0.1809	0	2213.744	1813.278	0.00080544
Great Lakes	0.3655	0	491.162	311.642	0.00036106
Upper Great Plains*	0.22	0	749.355	584.497	0.00033157
Far West*	0.22	0	1459.012	1138.029	0.00064558
Florida*	0	0.02	2018.170	1977.807	0.00008118
Louisiana	0	0.2624	1283.138	946.443	0.00067718
Texas	0	0.0881	97.159	88.600	0.00001722

* Indicates elasticity taken from Benirschka et al. (1996).

Foreign supply functions are estimated using the quantity of 1998-2000 average actual exports to the United States. Exports are converted from raw to refined form and estimated utilizing a three-year average world price of refined sugar, as shown in equation (3):

$$S_m(Q_m) = d_m + e_m P_m^{REF} . \qquad (3)$$

Parameters for each foreign supply equation are listed in Table 4.5.

Table 4.5. Foreign supply equation parameters

Region	Raw (Cane) Elasticity	Calibrated Supply (1000 tons)	Intercept (d)	Slope (e)
Mexico	0.05	118.449	112.527	0.0000301
Caribbean	0.01	273.161	270.430	0.0000139
SA Region 1	0.02	201.116	197.094	0.0000204
SA Region 2	0.02	75.959	74.440	0.0000077
SA Region 3	0.02	107.173	105.030	0.0000109
CA Region 1	0.02	100.069	98.068	0.0000102
CA Region 2	0.02	120.653	118.241	0.0000123
South Africa	0.0057	32.611	32.425	0.0000009
Australia	0.03	117.882	114.346	0.0000180
Philippines	0.02	171.319	167.893	0.0000174

Source: Elasticities taken from Benirschka et al. (1996).

Mathematical Form of the Model

The objective function maximizes social welfare by computing surplus across U.S. consumers, and domestic and foreign producers with an implicit price model. The mathematical representation of the model's objective function is shown as follows:

(4)

$$\begin{aligned}\max surplus =& \sum_i [\int_0^{Qi^*} D_i^{-1}(Q_i^D)dQ_i - D_i(Q_i)Q_i] + \sum_j [-\int_{dj}^{Qj^*} S_j^{-1}(Q_j)dQ_j + S_j(Q_j)Q_j] \\ &+ \sum_m [-\int_{dm}^{Qm^*} S_m^{-1}(Q_m)dQ_m + S_m(Q_m)Q_m] - \sum_j\sum_i t_{ji}q_{ij}^S - \sum_j\sum_h\sum_i [t_{jh} + PC_h + t_{hi}/\alpha]r_{jhi}^S \\ &- \sum_m\sum_p\sum_h\sum_i [t_{mp} + handle_p + t_{ph} + PC_h + t_{hi}/\alpha]r_{mphi}^S - \sum_m\sum_p\sum_h\sum_i r_{mphi}^S(tar) * tariff \\ &- \sum_m\sum_p\sum_h\sum_i r_{mphi}^S(no-tar)/\alpha * pwedge,\end{aligned}$$

where the first term enclosed in brackets represents U.S. consumer surplus for refined sugar from all U.S. consuming regions, *i*. The second bracketed term represents producer surplus of domestically produced refined sugar from producing region *j*. The third set of bracketed terms defines producer surplus for foreign producing countries, *m*.

Various expenditures incurred from sugar trade are the remaining objective function terms. The fourth term in equation (4) sums transportation costs incurred from U.S. beet sugar producing regions to U.S. consuming regions. The fifth set of bracketed equations sums transportation costs incurred from cane producing region *j* to refinery *h*, processing costs at refinery *h*, and transportation costs from *h* to consuming region *i*, divided by the conversion rate to keep all flows in raw form. The sixth set of bracketed terms tracks sugar flows from exporting country *m* to U.S. port *p*, to refinery *h*, to consuming region *i*. Transportation costs in refined terms from *h* to *i* are divided by the conversion rate to keep all foreign trade flows in raw sugar form. The final two terms separate quantities of raw imported sugar flows into tariff and non-tariff categories. Term seven calculates the total cost of tariffs imposed upon above-quota raw sugar exports. The last term calculates sugar refinery profit, essentially the price wedge driven between world and U.S. price under the current U.S. TRQ system. In the model, a 10-cent price wedge is utilized to incorporate these refinery rents.

To summarize the model, prices are determined post-optimality by inverting the demand functions and evaluating them at optimal consumption levels. The price received is computed by taking the price paid and subtracting transportation, processing, handling, processor rents, and tariff costs.

Model Constraints

The model involves several constraints. Both types of sugar are needed to evaluate the costs associated with the sugar flows. The objective function is optimized subject to the following constraints:

(5) $$Q_i^D = \sum_j q_{ji}^s + \sum_{jh} r_{jhi}^s / \alpha + \sum_{mph} r_{mphi}^s / \alpha$$

(6) $$R_j^S = \sum_{hi} r_{jhi}^s$$

(7) $$Q_j^S = \sum_i q_{ji} + R_j^S / \alpha$$

(8) $$R_j^S = Q_j^S * \alpha$$

(9) $$R_m^S = Q_m^S * \alpha$$

(10) $$Q_m^S = R_m^S / \alpha$$

(11) $$R_m^S = \sum_{phi} r_{mphi}^s$$

(12) $$R_m^S = \sum_{phi} [(no - tar) r_{mphi}^s + (tar) r_{mphi}^s]$$

(13) $$\sum_{phi} r_{mphi}^s (no - tar) \le quota_m$$

(14) $$\sum_{ji} r_{jhi}^s + \sum_{mpi} r_{mphi}^s \le melt_h \, .$$

Total refined sugar consumed by all sugar-consuming regions is defined in equation (5) by adding U.S. refined beet sugar, refined equivalents of U.S. cane sugar, and imports of refined equivalents of foreign cane sugar. Total raw sugar equivalent supply flows across *j*, *h*, and *i* equal the total U.S. raw sugar supply as shown in (6). Equation (7) sets the total amount of U.S. refined sugar supply equal to the sum of all refined sugar production from region *j* to *i* and total cane sugar production in refined equivalents. Equations (8) and (9) show the conversion of refined sugar for regions *j* and *m,* respectively, into raw equivalents.

Export constraints are shown by equations (10) through (13). In equation (10), total refined sugar supply from *m* is set equal to the total amount of raw sugar divided by the conversion factor. The sum of sugar flows across *m, p, h,* and *i* in raw equivalents is defined as the total raw sugar exported in (11). Equation (12) sets the total quantity of raw sugar flows equal to the quantity of imported sugar flows across *m, p, h,* and *i* as within-quota, non-duty tariff sugar and above-quota, high-duty tariff sugar. Equation (13) sets all non-duty, non-tariff sugar imports to be less than or equal to the U.S. quota. Finally, equation (14) sets the raw sugar supply at refineries provided by U.S. producing region *j* and foreign exporting countries to be less than or equal to the daily melting capacity of each refinery.

Sugar Refinery Data

Table 4.6 shows the 10 U.S. cane sugar refineries and their daily melting capacities included in the model. The sugar cane refineries are located in 7 states with daily melting capacities ranging from 850-3,000 tons of raw sugar.

Transportation Costs

Mileage distances for the various transportation routes used in the contiguous U.S. are found using Rand McNally Online (2002). Distances to and from each location are listed in Appendix A: Tables A.1., A.2, A.3, and A.4.

Table 4.6. Company, location and capacity of U.S. sugar refineries

Company	Location	Daily Melting Capacity (tons raw sugar)
Domino Sugar Corp.	Baltimore, MD	3,000
	Brooklyn, NY	2,000
	Chalmette, LA	3,000
California and Hawaiian Sugar Co.	Crockett, CA	3,000
Imperial Holly Corp.	Sugar Land, TX	1,950
Florida Crystals Refinery	South Bay, FL	925
Refined Sugars, Inc	Yonkers, NY	2,000
Savannah Foods and Industries, Inc.	Port Wentworth, GA	3,100
Everglades Sugar Refinery, Inc.	Clewiston, FL	850
Colonial Sugars, Inc.	Gramercy, LA	2,150

Source: USDA-ERS (June 1996).

The estimated refined and raw sugar rail freight rate is determined with freight rates from the Burlington Northern Santa Fe (BNSF) Railroad website (2002). The rail rate function expresses rate as a function of miles. Refined sugar transportation rates on the BNSF website are utilized in the model while corn syrup rates are used for raw sugar transportation rates. Raw sugar is in a liquid form, and corn syrup is a close substitute. The following notation is used to define rail functions:

$R_{refined/raw}$ = freight rates in dollars per ton for sugar shipments for either refined or raw sugar

$M_{refined/raw}$ = distances in miles from the various points of transportation.

Transportation cost of refined sugars from U.S. beet-producing regions and U.S. refineries to domestic consuming regions is

(25) $$R_{refined}=20.8992 + 0.02497 (M_{refined}).$$

Transportation costs of raw sugar from ports and U.S. cane-producing regions to refineries is

(26) $R_{raw}=15.3917 + 0.01037(M_{raw})$.

Since both raw and refined sugar may be sent either by truck or rail, the cost-minimizing method is assumed. The cost for truck mileage is higher than rail in each shipping route, and as a result, no trucking costs are utilized in the model. Sample truck rate quotes given from various local trucking companies range from $1.25-$1.45 per hundred pounds for refined sugar and $2.10-$2.15 pounds for raw sugar. Total rail costs for each transportation flow are listed in Appendix A: Tables A.7, A.8, A.9, and A.10.

An equation is estimated for ocean freight costs from sugar exporting countries to U.S. ports. The cost is determined with actual ocean freight rates from selected sample routes provided by American Crystal Sugar Company. Oceanic mileage rates between ports are found using the Partnership Shipping Portal Online website (1999) and also Maritime Chain Online (2000). These distances in nautical miles are listed in Appendix A, Table A.5.

The raw sugar ocean transportation rate equation also expresses rate as a function of miles in dollars per ton. Oceanic rate data from American Crystal Sugar Company are used to estimate equation (27):

(27) $OR_{mp} = 1515.149 + 0.1818\ M_{mp}$,

where

OR_{mp} =ocean freight rates for raw sugar shipped

M_{mp} =ocean distance in nautical miles between foreign country *m* and U.S. port *p*.

Total oceanic transportation costs for each destination are listed in Appendix A, Table A.6.

The Base and Alternative Scenarios

This study considers several different scenarios. The baseline scenario is first described under current conditions, followed by four short-run and four long-run counterfactual scenarios.

The baseline scenario incorporates current production, consumption, prices, and marketing conditions under existing trade policy. The TRQs in effect for 2002 are used in the baseline model. The high-duty tariff for all foreign exporters is $0.1536 cents per pound with the exception of Mexico's reduced high-duty tariff of $0.1058 cents per pound. In the baseline, both U.S. producers and consumers are subject to the fiscal years 1998-2000 average wholesale refined beet sugar price of $0.2486 per pound. Foreign exporters are subject to the 1998-2000 average world refined sugar price of $0.0984 per pound.

Short-run counterfactual scenarios are as follows:

(1) Counterfactual scenario 1 considers NAFTA conditions in 2008 when U.S. sugar trade with Mexico becomes completely liberalized. In this case, Mexico's sugar exports are modeled as "unlimited" but are given an upper limit of 500,000 metric tons (MT) to reflect Mexican production capacity limits. All other 2001 TRQ levels and trade policies remain intact.

(2) Counterfactual scenario 2 also considers 2008 NAFTA conditions, with Mexican sugar exports at 500,000 MT and zero tariffs, combined with

restricted Brazilian exports. Brazil is not allocated a TRQ under this scenario. All other 2001 TRQ levels and policies remain constant.

(3) Counterfactual scenario 3 examines a combination of Mexican export levels of 500,000 MT and an increased Brazilian duty-free quota. Effects are evaluated with Brazil's quota at both the 300,000 and 600,000 MT levels. Brazil has immense production capacity for sugar and would be capable of exporting much larger amounts than its current TRQ allows.

(4) Counterfactual scenario 4 examines large-scale trade liberalization for all potential FTAA member countries. TRQs are set at 600,000 MT for the following country regions: the Caribbean, SA1, SA2, SA3, CA1, and CA2. Mexico's TRQ is capped at 500,000 MT. This scenario shows effects of dramatic increases in export potential under an FTAA.

These scenarios are evaluated with and without the $0.10 per pound refinery rents included in the objective function. Processor rents create the price wedge driven between world and U.S. price under the current trade environment. These rents may not be possible in a large-scale free trade environment. To simulate future effects under highly liberalized trade conditions, these rents are eliminated.

Potential effects of an FTAA are also evaluated in long-run conditions using a more elastic export supply equations for selected countries. Texas' supply elasticity of 0.08 is utilized to simulate a long-run production stage. Long-run counterfactual scenarios include allowing the individual countries of Mexico, Brazil, and the Caribbean to hold a more elastic export supply equation in three separate simulations. All other countries remain at original supply equations. The fourth simulation reports effects when all potential FTAA members are in their long-run export supply stage, holding all non-FTAA and U.S. producing regions at their original supply equations.

CHAPTER V. RESULTS

Introduction

This chapter reports the results of the GAMS optimization for each scenario. Producer surplus, exports by foreign exporters, production by U.S. producers, and price received are reported. Price received by producers is a weighted average price, as prices differ depending on the sugar shipping area. Consumer surplus, consumption, and price paid by U.S. sugar consumers are reported. For counterfactual scenarios, percent changes from the baseline results are reported under each category. Each short-run counterfactual scenario is evaluated with and without the $0.10 per pound price wedge from refinery rents. A second set of counterfactual scenarios utilizes more elastic export supply equations for selected countries to simulate long-run equilibrium results.

All short-run output results are first reported under current U.S. trade conditions, utilizing the 2001 tariff rate quotas (TRQs) assigned to each exporting country. Several trade liberalization scenarios are tested by adjusting potential FTAA member TRQ levels. The first alternative scenario examines the effects of 2008 NAFTA conditions when Mexico is allowed exports capped at 500,000 metric tons (MT); TRQ levels for all other countries and regions remain at 2001 allocations. A second counterfactual scenario examines 2008 NAFTA levels when Mexico holds export levels of 500,000 MT and Brazilian sugar imports are restricted to zero. The third counterfactual scenario examines trade effects under two Brazilian TRQ levels of 300,000 and 600,000 MT when Mexico is capped at 500,000 MT. Finally, the fourth scenario examines the effects of large-scale liberalization, allowing regions SA1, SA2, SA3, CA1, CA2, and the Caribbean TRQs of 600,000 MT. Mexico is held at its NAFTA-imposed level at 500,000 MT in the last scenario.

Long-run counterfactual scenarios use an increased elasticity for foreign country export supply equations. It is assumed that large-scale free trade will provide incentive for investment in foreign sugar production, increasing sugar export ability. This set of counterfactual scenarios uses Texas' supply elasticity of 0.08 for foreign supply export supply equations. Processor rents are considered impossible in the long-run equilibrium and are not evaluated. Countries evaluated have capped exports at 600,000 MT to simulate "unlimited" exports. Four long-run alternative scenarios are reported. The first three scenarios involve liberalization of individual countries: Mexico, Brazil, and the Caribbean. The fourth scenario includes all potential FTAA countries in long-run conditions.

Baseline Results

In the baseline, exporter supply functions are calibrated to a world refined sugar price of $0.0984 per pound. U.S. regional supply equations are calibrated to a refined sugar price of $0.2486. 2001 TRQ levels, previously shown in Table 2.1, are used in the baseline results. Tariffs imposed on above-quota exports are $0.1058 for Mexico and $0.1536 for other foreign exporting countries. The total amount of producer surplus, foreign exports and U.S. sugar production, and weighted average prices received are shown in Table 5.1.

Table 5.1. Baseline results for foreign and U.S. producer surplus, total exports and production, and prices received

Region	Surplus (1000 US $)	Exports/ Production (1000 tons)	Price Received (US $ per pound)
Mexico	17,796	104.179	0.0873
Caribbean	41,124	239.859	0.0858
SA1	29,027	175.111	0.0829
SA2	10,444	66.123	0.0790
SA3	15,854	93.355	0.0850
CA1	14,382	87.168	0.0825
CA2	16,520	105.093	0.0786
South Africa	4,260	28.723	0.0742
Australia	14,764	101.651	0.0727
Philippines	22,545	148.959	0.0757
Red River Valley	846,900	1944.799	0.2386
Great Lakes	171,515	430.888	0.2427
Upper Great Plains	279,060	656.747	0.2377
Far West	531,674	1273.479	0.2331
Florida	706,258	1778.683	0.2001
Louisiana	387,149	1077.729	0.2019
Texas	33,100	84.506	0.2031
Foreign Totals/Averages	186,720	1150.220	0.0814
U.S. Totals/Averages	2,955,660	7246.830	0.2225
Foreign and U.S. Total	3,142,381	8397.050	

In the baseline, the Caribbean and SA1 have the highest exporter surpluses and exports to the United States. Mexico receives the highest foreign price received at $0.0873 per pound, likely stemming from the lower tariff imposed in 2001. The Red River Valley has the largest producer surplus for beet-producing regions while Florida is the most competitive cane-producing region.

In the baseline, consumer demands are calibrated to a price of $0.2486. Table 5.2 reports consumer surpluses, consumption, and prices paid in the baseline.

Table 5.2. Baseline results for consumer surplus, consumption, and price paid per region

Region	Consumer Surplus Per Region (1000 US$)	Consumption Per Region (1000 tons)	Price Paid (US$ per pound)
New York City	1,106,053	1773.080	0.2622
Atlanta	545,641	871.080	0.2596
Miami	308,444	487.250	0.2530
New Orleans	325,225	517.300	0.2573
Houston	503,642	806.000	0.2612
St. Louis	238,609	381.020	0.2598
Chicago	817,441	1299.800	0.2571
Minneapolis	222,048	350.200	0.2520
Billings	51,407	81.020	0.2515
Seattle	184,775	295.920	0.2616
Denver	256,371	407.890	0.2575
San Francisco	714,512	1126.480	0.2517
Totals/Average	5,274,173	8397.050	0.2579

Short-Run Equilibrium Counterfactual Scenarios

Counterfactual Scenario 1

The first counterfactual scenario examines NAFTA conditions in 2008 by allowing Mexico 500,000 MT and a zero tariff. This scenario holds all other TRQ levels at 2001 levels with the tariff of $0.1536.

Table 5.3 shows that, under this scenario, Mexico increases its surplus nearly 120%. Mexico's price becomes tied to the U.S. domestic price, rising 114% from the baseline results. Mexican exports to the United States. also increase 5% from the baseline. All other foreign countries and U.S. producing regions experience losses of less than 1%, indicating a small impact on the U.S. industry.

Table 5.3. Percent changes for producer surplus, exports/production, and prices received with Mexico duty-free exports at 500,000 MT

Region	Surplus	Exports/ Production	Price Received
Mexico	119.990	5.098	114.3946
Caribbean	-0.330	-0.003	-0.3285
SA1	-0.340	-0.006	-0.3375
SA2	-0.360	-0.006	-0.3544
SA3	-0.330	-0.006	-0.3294
CA1	-0.340	-0.006	-0.3392
CA2	-0.590	-0.006	-0.5839
South Africa	-0.380	-0.002	-0.3810
Australia	-0.390	-0.009	-0.3832
Philippines	-0.390	-0.006	-0.3899
Red River Valley	-0.130	-0.021	-0.1188
Great Lakes	-0.140	-0.042	-0.1168
Upper Great Plains	-0.130	-0.025	-0.1193
Far West	-0.140	-0.025	-0.1216
Florida	-0.140	-0.002	-0.1425
Louisiana	-0.160	-0.032	-0.1401
Texas	-0.140	-0.010	-0.1396
Foreign Totals	11.100	0.460	11.3318
U.S. Totals	-0.140	-0.020	-0.1281
Total	0.530	0.050	

U.S. consumer surplus, demand, and price results remain mostly unchanged under this scenario as shown in Table 5.4. Consumers increase their surplus and consumption less than 1% under this trade scenario, indicating that allowance of Mexican exports in the short-run has little impact on consumers.

No changes result when processor rents are possible. Mexico’s tariff is close to the \$0.10 price wedge eliminated in the baseline. When this wedge is added into the objective function and Mexico’s tariff is eliminated, the effects are absorbed, resulting in no change.

Table 5.4. Percent changes for consumer surplus, consumption, and prices paid with Mexico duty-free exports at 500,000 MT

Region	Surplus	Demand	Price Paid
New York City	0.09	0.05	<0.01
Atlanta	0.09	0.05	<0.01
Miami	0.09	0.04	<0.01
New Orleans	0.09	0.05	<0.01
Houston	0.09	0.05	<0.01
St. Louis	0.09	0.05	<0.01
Chicago	0.09	0.05	<0.01
Minneapolis	0.09	0.04	<0.01
Billings	0.09	0.04	<0.01
Seattle	0.09	0.05	<0.01
Denver	0.09	0.05	<0.01
San Francisco	0.09	0.04	<0.01
Totals	0.09	0.05	

Counterfactual Scenario 2

This scenario examines trade conditions when Brazilian exports are completely restricted. Mexico maintains its export limit at the 500,000 MT level with no export restrictions on sugar as in 2008 under NAFTA. Results from this scenario are shown in Table 5.5.

Brazil experiences large negative effects from the quota restriction. Mexico increases its exports nearly 5.6%, and surplus and price received by 130 and 124%, respectively. Total foreign exports fall by nearly 15%, but foreign price received increases by nearly 24%. U.S. producers increase total production by less than 1%. Total U.S. producer surplus and price received increases by 4%.

Consumers lose from this scenario, as shown in Table 5.6. Without Brazilian exports, reduced supply causes total consumer surplus to fall nearly 3%. Consumption falls 1.43%, and price paid for sugar remains unchanged from the baseline.

Table 5.5. Percent changes for producer surplus, exports/production, and prices received with Mexico at 500,000 MT and Brazil restricted

Region	Surplus	Exports/ Production	Price Received
Mexico	130.820	5.595	124.4425
Cuba	0.000	0.000	0.0000
Caribbean	9.850	0.097	9.7697
SA1	-2963.660	-99.429	-65.5565
SA2	10.670	0.195	10.5069
SA3	9.920	0.195	9.7585
CA1	10.220	0.195	10.0638
CA2	10.780	0.195	10.6180
South Africa	11.380	0.055	11.3384
Australia	11.670	0.295	11.4185
Philippines	12.570	0.195	12.3953
Red River Valley	3.890	0.619	3.5378
Great Lakes	4.270	1.252	3.4779
Upper Great Plains	4.460	0.843	3.9674
Far West	4.540	0.846	4.0452
Florida	4.650	0.076	4.6127
Louisiana	5.280	1.049	4.6616
Texas	4.830	0.340	4.6439
Foreign Totals	-440.240	-14.500	23.8535
U.S. Totals	4.460	0.640	4.0841
Total	-21.970	-1.430	

Table 5.6. Percent changes for consumer surplus, consumption, and prices paid with Mexico at 500,000 MT and Brazil restricted

Region	Surplus	Demand	Price Paid
New York City	-2.69	-1.35	<0.01
Atlanta	-2.99	-1.51	<0.01
Miami	-2.96	-1.49	<0.01
New Orleans	-2.98	-1.50	<0.01
Houston	-3.00	-1.51	<0.01
St. Louis	-2.68	-1.35	<0.01
Chicago	-2.67	-1.34	<0.01
Minneapolis	-2.64	-1.33	<0.01
Billings	-2.95	-1.49	<0.01
Seattle	-3.00	-1.51	<0.01
Denver	-2.98	-1.50	<0.01
San Francisco	-2.95	-1.49	<0.01
Totals	-2.84	-1.43	

When the processor rents are possible, effects from trade for most producing regions remain the same with the exception of Mexico as shown in Table 5.7. Mexico's surplus drops to a 10% gain in surplus and an export increase of less than 1%. Mexico experiences a price increase of nearly 10%, much different than its previous increase of 124%. Mexico's zero tariff advantage is absorbed by processor rents, but the elimination of Brazilian quota still creates incentive for increased exports. All other foreign countries and U.S. regions remain mainly unchanged.

Table 5.7. Percent changes for producer surplus, exports/production, and prices received with Mexico at 500,000 MT and Brazil restricted, processor rents possible

Region	Surplus	Exports/ Production	Price Received
Mexico	10.240	0.497	9.9923
Caribbean	10.190	0.100	10.1067
SA1	-2963.660	-99.429	-64.9397
SA2	11.050	0.201	10.8812
SA3	10.260	0.201	10.0946
CA1	10.590	0.201	10.4224
CA2	11.170	0.201	11.0119
South Africa	11.810	0.057	11.7605
Australia	12.270	0.304	12.0080
Philippines	12.950	0.201	12.7703
Red River Valley	4.020	0.640	3.6568
Great Lakes	4.410	1.294	3.5949
Upper Great Plains	4.590	0.868	4.0869
Far West	4.670	0.872	4.1670
Florida	4.800	0.079	4.7546
Louisiana	5.440	1.080	4.8020
Texas	4.970	0.350	4.7838
Foreign Totals	-451.440	-14.960	10.4111
U.S. Totals	4.600	0.660	4.2122
Total	-22.500	-1.480	

Table 5.8 shows that consumers lose slightly more surplus and demand when processor rents are possible. The loss of nearly 5% of Mexican exports from when processor rents were not possible decreases the sugar supply slightly, causing these losses for consumers.

Table 5.8. Percent changes for consumer surplus, consumption, and prices paid with Mexico at 500,000 MT and Brazil restricted, processor rents possible

Region	Surplus	Demand	Price Paid
New York City	-2.78	-1.40	<0.01
Atlanta	-3.08	-1.55	<0.01
Miami	-3.05	-1.53	<0.01
New Orleans	-3.07	-1.55	<0.01
Houston	-3.09	-1.55	<0.01
St. Louis	-2.77	-1.39	<0.01
Chicago	-2.76	-1.39	<0.01
Minneapolis	-2.73	-1.38	<0.01
Billings	-3.04	-1.53	<0.01
Seattle	-3.09	-1.56	<0.01
Denver	-3.07	-1.55	<0.01
San Francisco	-3.04	-1.53	<0.01
Totals	-2.93	-1.48	

Counterfactual Scenario 3

The third counterfactual scenario examines potential trade flows under 2008 NAFTA conditions combined with possible Brazilian duty-free quotas of 300,000 MT and 600,000 MT to exemplify possible FTAA conditions. Both quota levels are evaluated to find whether greater impacts are possible with larger exports. Mexican tariff-free exports are considered “unlimited” and capped at 500,000 MT.

This scenario’s results are identical under Brazilian exports at 300,000 MT or 600,000 MT. Table 5.9 reports percentage changes in producer results. Mexico increases exports by 5%, price received by 114%, and surplus by nearly 120% under this scenario. Mexico’s price received is now closer to the U.S. raw cane sugar price at

Table 5.9. Percent changes for producer surplus, exports/production, and prices received with Mexico at 500,000 MT, and Brazil at 300,000 MT and 600,000 MT

Region	Surplus	Exports/ Production	Price Received
Mexico	119.910	5.092	114.3164
Caribbean	-0.480	-0.004	-0.4752
SA1	2.030	1.321	1.4978
SA2	-0.510	-0.008	-0.5079
SA3	-0.490	-0.008	-0.4785
CA1	-0.510	-0.008	-0.5058
CA2	-0.520	-0.008	-0.5132
South Africa	-0.550	-0.002	-0.5475
Australia	-0.560	-0.013	-0.5523
Philippines	-0.570	-0.008	-0.5669
Red River Valley	-0.190	-0.030	-0.1708
Great Lakes	-0.200	-0.060	-0.1679
Upper Great Plains	-0.190	-0.036	-0.1714
Far West	-0.200	-0.037	-0.1748
Florida	-0.210	-0.003	-0.2047
Louisiana	-0.230	-0.045	-0.2014
Texas	-0.210	-0.015	-0.2006
Foreign Totals	11.360	0.660	11.4927
U.S. Totals	-0.200	-0.030	-0.1840
Total	0.490	0.060	

$0.1868 per pound. Brazil increases exports by 1.32%, price received by nearly 1.5%, and surplus by 2%. All other foreign exporting countries experience losses of less than 1% in all category levels. Total foreign exports increase by less than 1%, but price received and surplus increase by 11%. Total U.S. producer surplus, production, and price received fall less than 1% under each category.

Table 5.10 shows minimal consumer changes under this scenario. Consumer surplus and actual consumption both increase less than 1% with very small change in price paid.

When the price wedge is eliminated from this scenario, results show larger differences from the previous simulation as shown in Table 5.11. Under this type of

Table 5.10. Percent changes for consumer surplus, consumption, and prices paid with Mexico at 500,000 MT, and Brazil at 300,000 MT and 600,000 MT

Region	Surplus	Demand	Price Paid
New York City	0.13	0.07	<0.01
Atlanta	0.13	0.07	<0.01
Miami	0.13	0.06	<0.01
New Orleans	0.13	0.06	<0.01
Houston	0.13	0.07	<0.01
St. Louis	0.13	0.07	<0.01
Chicago	0.13	0.06	<0.01
Minneapolis	0.13	0.06	<0.01
Billings	0.13	0.06	<0.01
Seattle	0.13	0.07	<0.01
Denver	0.13	0.06	<0.01
San Francisco	0.13	0.06	<0.01
Totals	0.13	0.06	

sugar trade liberalization, Mexican producer surplus, exports, and price received fall by 1%. Mexico's advantage of tariff elimination is absorbed by processor rents. Brazil experiences slight gains to the previous results without processor rents. Similar negative changes result for all other foreign countries and U.S. producing regions without processor rents. Total U.S. surplus, production, and price received fall by less than 1% while total foreign producers gain by less than 1% in all result categories.

Consumer gains are less under this liberalization scheme with processor rents, as shown in Table 5.12. Consumers lose slightly when processor rents are eliminated. The loss of some Mexican exports results in smaller gains in surplus for consumers, but still less than 1%.

Identical results under both 300,000 MT and 600,000 MT suggest Brazil's short-run export supply equation is rather inelastic. Raising the Brazilian quota level above 300,000 MT will not change producer results.

Table 5.11. Percent changes for producer surplus, exports/production, and prices received with Mexico at 500,000 MT, and Brazil at 300,000 MT and 600,000 MT, processor rents possible

Region	Surplus	Exports	Price Received
Mexico	-0.150	-0.006	-0.1419
Caribbean	-0.150	-0.001	-0.1468
SA1	2.520	1.327	1.9905
SA2	-0.160	-0.003	-0.1545
SA3	-0.150	-0.003	-0.1500
CA1	-0.150	-0.003	-0.1482
CA2	-0.160	-0.003	-0.1561
South Africa	-0.170	-0.001	-0.1665
Australia	-0.170	-0.004	-0.1641
Philippines	-0.170	-0.003	-0.1673
Red River Valley	-0.060	-0.009	-0.0519
Great Lakes	-0.060	-0.018	-0.0511
Upper Great Plains	-0.060	-0.011	-0.0521
Far West	-0.060	-0.011	-0.0531
Florida	-0.060	-0.001	-0.0623
Louisiana	-0.070	-0.014	-0.0612
Texas	-0.060	-0.005	-0.0610
Foreign Totals	0.260	0.200	0.1870
U.S. Totals	-0.060	-0.010	-0.0560
Total	-0.040	0.020	

Counterfactual Scenario 4

The last counterfactual scenario examines potential FTAA liberalization for all Caribbean, and South and Central American countries' sugar trade with the United States. Regions SA1, SA2, SA3, CA1, CA2, and the Caribbean have imposed quotas of 600,000 MT to demonstrate "unlimited" exports. High-duty tariffs are dropped to zero to allow complete access by these countries. Mexico is restricted to a 500,000 MT at zero tariff.

Table 5.12. Percent changes for consumer surplus, consumption, and prices paid with Mexico at 500,000 MT, and Brazil at 300,000 MT and 600,000 MT, processor rents possible

Region	Surplus	Demand	Price Paid
New York City	0.04	0.02	<0.01
Atlanta	0.04	0.02	<0.01
Miami	0.04	0.02	<0.01
New Orleans	0.04	0.02	<0.01
Houston	0.04	0.02	<0.01
St. Louis	0.04	0.02	<0.01
Chicago	0.04	0.02	<0.01
Minneapolis	0.04	0.02	<0.01
Billings	0.04	0.02	<0.01
Seattle	0.04	0.02	<0.01
Denver	0.04	0.02	<0.01
San Francisco	0.04	0.02	<0.01
Totals	0.04	0.02	

Table 5.13 reports gains for all liberalized countries under this scenario. All potential FTAA countries increase their producer surplus and price received over 100%. Exports from these countries increase marginally between 1% and 4%. Total foreign exports rise over 2.6%. The Red River Valley, Great Lakes, and Far West lower sugarbeet production under this trade condition. Texas is the only cane-producing region that loses surplus and falls in price, but does not lower production. The Upper Great Plains, Florida, and Louisiana experience small gains from this liberalization strategy. Overall, the U.S. production falls by less than 1% and price by 4%.

Table 5.14 shows individual consuming regions varied changes under this scenario. Half of the U.S. consuming regions lose demand and surplus in the short run. The other half experiences gains from this scenario. Consuming regions where the main source of sugar came from U.S. producing regions that decreased production experience a short-run shortage of sugar. Other regions gain from increased sugar exports. Total consumer demand falls by less than 1%, surplus increases less than 1%, and price changes remain very small in the short run.

Table 5.13. Percent changes in producer surplus, exports/production, and prices received under large-scale trade liberalization

Region	Surplus	Exports/ Production	Price Received
Mexico	135.590	6.019	128.8622
Caribbean	132.330	1.780	130.4541
SA1	135.400	3.700	131.6156
SA2	151.520	3.735	147.3301
SA3	134.930	3.981	131.1477
CA1	138.500	3.769	134.7160
CA2	157.720	3.756	153.4720
South Africa	6.970	-0.100	7.0628
Australia	17.340	-0.453	17.8207
Philippines	5.400	0.125	5.2960
Red River Valley	-11.160	-1.799	-10.2771
Great Lakes	-12.120	-3.639	-10.1200
Upper Great Plains	6.230	1.177	5.5329
Far West	-9.230	-1.742	-8.3360
Florida	1.070	0.115	1.0630
Louisiana	1.780	2.884	1.6991
Texas	-1.410	0.116	-1.3573
Foreign Totals	109.880	2.620	107.9977
U.S. Totals	-4.500	-0.440	-4.1697
Total	2.300	-0.020	

Processor rents absorb gains from trade under this liberalization scenario shown in Table 5.15. When processor rents are possible, foreign producers receive a price close to world price. The specified liberalized countries receive gain in all categories from this trade scenario, with the exception of Mexico, with falling exports, producer surplus, and price received. Non-FTAA countries and United States producing regions experience minimal losses of less than 1%. Total United States supply of sugar increases less than 1%.

Table 5.14. Percent changes in consumer surplus, demand, and prices paid under large-scale trade liberalization

Region	Surplus	Demand	Price Paid
New York City	-4.30	-2.17	<0.01
Atlanta	-0.26	-0.13	<0.01
Miami	-9.64	-4.94	<0.01
New Orleans	-7.91	-4.03	<0.01
Houston	-7.27	-3.70	<0.01
St. Louis	7.95	3.90	<0.01
Chicago	7.96	3.91	<0.01
Minneapolis	7.89	3.87	<0.01
Billings	-4.10	-2.07	<0.01
Seattle	6.31	3.11	<0.01
Denver	-4.13	-2.09	<0.01
San Francisco	6.22	3.06	<0.01
Totals	0.08	-0.02	

Table 5.15. Percent changes in producer surplus, exports/production, and prices received under large-scale trade liberalization, processor rents possible

Region	Surplus	Exports/ Production	Price Received
Mexico	-0.540	-0.023	-0.5232
Caribbean	1.890	0.654	1.6317
SA1	2.120	1.320	1.5890
SA2	5.570	1.320	5.0142
SA3	1.740	1.319	1.2289
CA1	4.910	1.319	4.3781
CA2	10.340	1.319	9.7764
South Africa	-0.880	-0.003	-0.8803
Australia	-0.600	-0.014	-0.5834
Philippines	-0.640	-0.010	-0.6306
Red River Valley	-0.210	-0.034	-0.1915
Great Lakes	-0.230	-0.068	-0.1882
Upper Great Plains	-0.210	-0.041	-0.1922
Far West	-0.220	-0.041	-0.1960
Florida	-0.230	-0.004	-0.2296
Louisiana	-0.250	-0.051	-0.2258
Texas	-0.230	-0.017	-0.2250
Foreign Totals	2.300	0.740	2.0186
U.S. Totals	-0.220	-0.030	-0.2064
Total	-0.070	0.070	

When processor rents are possible, foreign producers receive a price close to world price. The specified liberalized countries receive gain in all categories from this trade scenario, with the exception of Mexico, with falling exports, producer surplus, and price received. Non-FTAA countries and U.S. producing regions experience minimal losses of less than 1%. Total U.S. supply of sugar increases less than 1%.

Consumers gain marginally from this simulation of trade liberalization as shown in Table 5.16. Consumer surplus and demand rise slightly with the large-scale liberalizations, but the price change is extremely small due to small export increases in the short run. Total U.S. sugar supply increases less than 1%, attributing to these very small gains.

Table 5.16. Percent changes in consumer surplus, demand, and prices paid under large-scale trade liberalization, processor rents possible

Region	Surplus	Demand	Price Paid
New York City	0.15	0.07	<0.01
Atlanta	0.15	0.07	<0.01
Miami	0.14	0.07	<0.01
New Orleans	0.15	0.07	<0.01
Houston	0.15	0.07	<0.01
St. Louis	0.15	0.07	<0.01
Chicago	0.15	0.07	<0.01
Minneapolis	0.14	0.07	<0.01
Billings	0.14	0.07	<0.01
Seattle	0.15	0.07	<0.01
Denver	0.15	0.07	<0.01
San Francisco	0.14	0.07	<0.01
Totals	0.15	0.07	

Long-Run Equilibrium Counterfactual Scenarios

Four counterfactual scenarios are evaluated with more elastic export supply equations for selected countries to measure long-run effects. It is assumed in the long-run that a FTAA will provide incentive for sugar exporting countries to invest in their domestic industries. As production capabilities become more advanced, export supply elasticities will increase, becoming more elastic. A more elastic export supply equation indicates larger sugar export capabilities. In each counterfactual scenario, Texas' supply elasticity of 0.08 is used for each country examined. All selected liberalized countries are evaluated under 600,000 MT to consider "unlimited" exports. Processor rents are assumed impossible in the long-run under this highly liberalized sugar trade environment.

Long-Run Counterfactual Scenario 1

The first long-run counterfactual scenario examines the effects of Mexico in the long run under increased supply elasticity. All other countries/regions remain at baseline conditions.

Table 5.17 reports effects of Mexico in the long run. Mexico increases exports by 9% and producer surplus and price received over 100%. Total foreign exports increase by less than 1%, as all other individual foreign countries experience negative effects of less than 1%. All U.S. producing regions experience negative impacts in all result categories of less than 1%. Total U.S. sugar supply increases by less than 1%.

Table 5.18 reports consumer data changes when Mexico is in its long-run production stage. U.S. consumers gain by less than 1% in both consumer surplus and demand. Price paid remains unchanged. The increase of less than 1% in U.S. supply when Mexico is at its long-run equilibrium results in these small percentage changes in both producer and consumer results from the baseline.

Table 5.17. Producer data percent changes with Mexico in long-run equilibrium

Region	Surplus	Exports/ Production	Price Received
Mexico	123.630	9.006	113.6218
Caribbean	-0.580	-0.005	-0.5773
SA1	-0.600	-0.010	-0.5947
SA2	-0.630	-0.010	-0.6227
SA3	-0.590	-0.010	-0.5774
CA1	-0.600	-0.010	-0.5961
CA2	-0.660	-0.010	-0.6524
South Africa	-0.670	-0.003	-0.6711
Australia	-0.690	-0.016	-0.6733
Philippines	-0.690	-0.010	-0.6852
Red River Valley	-0.230	-0.037	-0.2089
Great Lakes	-0.250	-0.074	-0.2054
Upper Great Plains	-0.230	-0.045	-0.2097
Far West	-0.240	-0.045	-0.2138
Florida	-0.250	-0.004	-0.2505
Louisiana	-0.280	-0.055	-0.2464
Texas	-0.250	-0.018	-0.2454
Foreign Totals	11.020	0.800	11.4308
U.S. Totals	-0.240	-0.040	-0.2251
Total	0.420	0.080	

Table 5.18. Consumer data percent changes with Mexico in long-run equilibrium

Region	Surplus	Demand	Price Paid
New York City	0.16	0.08	<0.01
Atlanta	0.16	0.08	<0.01
Miami	0.16	0.08	<0.01
New Orleans	0.16	0.08	<0.01
Houston	0.16	0.08	<0.01
St. Louis	0.16	0.08	<0.01
Chicago	0.16	0.08	<0.01
Minneapolis	0.16	0.08	<0.01
Billings	0.16	0.08	<0.01
Seattle	0.16	0.08	<0.01
Denver	0.16	0.08	<0.01
San Francisco	0.16	0.08	<0.01
Totals	0.16	0.08	

Long-Run Counterfactual Scenario 2

The next scenario reports results when Brazil's supply elasticity is increased to 0.08. A Brazilian quota of 600,000 MT indicates "unlimited" exports. All other countries remain unchanged from the baseline. Table 5.19 reports changes in producer results when Brazil's supply elasticity is 0.08. Brazilian exports increase over 12% in the long run. Brazilian producer surplus increases 128% and gains 116% in price received. However, total foreign sugar exports increase only 1.8% due to negative changes in all other foreign exporting countries. Total U.S. production decreases by less than 1%. Total sugar supply increases by less than 1%.

Table 5.19. Producer data percent changes with Brazil in long-run equilibrium.

Region	Surplus	Exports/ Production	Price Received
Mexico	-1.340	-0.059	-1.3130
Caribbean	-1.340	-0.012	-1.3284
SA1	128.010	12.398	116.3919
SA2	-1.450	-0.024	-1.4327
SA3	-1.350	-0.024	-1.3347
CA1	-1.390	-0.024	-1.3713
CA2	-1.460	-0.024	-1.4437
South Africa	-1.550	-0.007	-1.5439
Australia	-1.650	-0.036	-1.6159
Philippines	-1.540	-0.023	-1.5176
Red River Valley	-0.530	-0.084	-0.4814
Great Lakes	-0.580	-0.171	-0.4733
Upper Great Plains	-0.510	-0.098	-0.4600
Far West	-0.520	-0.098	-0.4690
Florida	-0.580	-0.009	-0.5771
Louisiana	-0.610	-0.122	-0.5404
Texas	-0.560	-0.040	-0.5383
Foreign Totals	18.350	1.820	18.7103
U.S. Totals	-0.550	-0.080	-0.5083
Total	0.570	0.180	

Consumers experience small changes due to this long-run scenario shown in Table 5.20. Consumers increase surplus and demand by less than 1% due to the small increase in sugar supply induced by Brazilian exports.

Table 5.20. Consumer data percent changes with Brazil in long-run equilibrium

Region	Surplus	Demand	Price Paid
New York City	0.37	0.18	0
Atlanta	0.37	0.18	0
Miami	0.36	0.18	0
New Orleans	0.35	0.17	0
Houston	0.35	0.18	0
St. Louis	0.37	0.18	0
Chicago	0.37	0.18	0
Minneapolis	0.36	0.18	0
Billings	0.35	0.17	0
Seattle	0.35	0.18	0
Denver	0.35	0.17	0
San Francisco	0.35	0.17	0
Totals	0.36	0.18	0

Long-Run Counterfactual Scenario 3

This scenario reports results for the Caribbean region with larger long-run supply elasticity. All other countries and U.S. producing regions remain at baseline conditions. As reported in Table 5.21, the Caribbean increases its exports by nearly 12% in the long run. Producer surplus and price received increase by 122% and 112%, respectively. Total foreign exports increase over 2%. U.S. production decreases by less than 1%.

Consumer surplus and demand increase by less than 1% as reported in Table 5.22. Small increases in consumer changes result from a very small decrease in price paid for sugar. The small increase in total sugar supply has downward pressure on the sugar price.

Table 5.21. Producer data percent changes with the Caribbean in long-run equilibrium

Region	Surplus	Exports/ Production	Price Received
Mexico	-1.950	-0.085	-1.9033
Caribbean	122.650	11.823	111.7681
SA1	-2.000	-0.035	-1.9778
SA2	-2.120	-0.035	-2.0901
SA3	-1.950	-0.035	-1.9267
CA1	-2.020	-0.035	-1.9931
CA2	-2.150	-0.035	-2.1217
South Africa	-2.250	-0.010	-2.2375
Australia	-2.310	-0.052	-2.2721
Philippines	-1.670	-0.025	-1.6539
Red River Valley	-0.760	-0.122	-0.6984
Great Lakes	-0.840	-0.247	-0.6866
Upper Great Plains	-0.570	-0.108	-0.5062
Far West	-0.580	-0.108	-0.5161
Florida	-0.840	-0.014	-0.8371
Louisiana	-0.670	-0.134	-0.5946
Texas	-0.610	-0.043	-0.5923
Foreign Totals	24.900	2.380	25.3178
U.S. Totals	-0.720	-0.100	-0.6640
Total	0.800	0.240	

Table 5.22. Consumer data percent changes with the Caribbean in long-run equilibrium

Region	Surplus	Demand	Price Paid
New York City	0.54	0.27	<0.01
Atlanta	0.53	0.27	<0.01
Miami	0.53	0.26	<0.01
New Orleans	0.38	0.19	<0.01
Houston	0.39	0.19	<0.01
St. Louis	0.53	0.27	<0.01
Chicago	0.53	0.27	<0.01
Minneapolis	0.53	0.26	<0.01
Billings	0.38	0.19	<0.01
Seattle	0.39	0.19	<0.01
Denver	0.38	0.19	<0.01
San Francisco	0.38	0.19	<0.01
Totals	0.48	0.24	

Long-Run Counterfactual Scenario 4

This scenario reports large-scale liberalization effects when all potential FTAA countries/regions have a long-run supply elasticity of 0.08. Countries/regions liberalized include Mexico, the Caribbean, SA1, SA2, SA3, CA1, and CA2. All other countries and U.S. producing regions remain at baseline conditions.

Table 5.23 shows producer result changes under this scenario. All FTAA member countries increase exports under this scenario, ranging from 10-21%. Total foreign sugar exports increase nearly 11%. Four of the seven U.S. producing regions decrease production under this trade environment. The Red River Valley, Louisiana, and Texas are the only regions to increase production. Total U.S. sugar production increases by less than 1%. Total sugar supply increases 1.66%.

Consumers' result changes under this scenario are shown in Table 5.24. Total consumer demand rises 1.66% and surplus increases 3.37% under large-scale liberalization. Price paid remains unchanged, or very small. This scenario generates the largest gains for consumers.

Summary of Results

In the short run, changes from baseline conditions with individual country trade liberalizations are small. Exporting countries have rather inelastic export supply equations in the short run, indicating small increases in exports immediately after FTAA trade policy is regulated.

Long-run results are simulated using larger supply elasticities for foreign export supply equations. Once foreign countries have established larger sugar production capacity, export supply equations will become more elastic, indicating larger sugar

Table 5.23. Producer data percent changes with all potential FTAA countries in long-run equilibrium

Region	Surplus	Exports/ Production	Price Received
Mexico	103.390	12.028	96.5721
Caribbean	103.550	10.670	94.7661
SA1	108.170	14.964	99.4262
SA2	111.980	18.476	100.1508
SA3	104.730	10.897	95.7013
CA1	130.250	18.756	115.3885
CA2	146.670	21.187	131.1168
South Africa	-19.790	-0.108	-19.7106
Australia	-17.010	1.700	-17.4132
Philippines	3.060	-0.288	3.3320
Red River Valley	-7.670	0.069	-6.9946
Great Lakes	-3.440	-2.536	-2.7975
Upper Great Plains	-2.200	-0.244	-1.9688
Far West	-3.560	-0.372	-3.1970
Florida	-9.710	-0.013	-9.6323
Louisiana	-10.040	2.990	-8.4971
Texas	-11.590	0.800	-11.0516
Foreign Totals	85.720	10.880	81.1570
U.S. Totals	-7.010	0.230	-6.4373
Total	-1.530	1.660	

Table 5.24. Consumer data percent changes with all potential FTAA countries in long-run equilibrium

Region	Surplus	Demand	Price Paid
New York City	4.64	2.29	<0.01
Atlanta	-3.29	-1.66	<0.01
Miami	6.84	3.36	<0.01
New Orleans	-2.62	-1.32	<0.01
Houston	7.39	3.63	<0.01
St. Louis	5.37	2.65	<0.01
Chicago	5.49	2.71	<0.01
Minneapolis	5.25	2.59	<0.01
Billings	3.42	1.69	<0.01
Seattle	1.24	0.62	<0.01
Denver	1.23	0.61	<0.01
San Francisco	2.52	1.25	<0.01
Totals	3.37	1.66	

export potential. The largest changes occur when all potential FTAA countries are allowed unlimited exports with a more elastic export supply equation.

Table 5.25 compares total short- and long-run result changes under large-scale liberalization and processor rents are not possible. Foreign exports grow by 8.26% from the short to long run, indicating larger production ability by foreign countries. Short-run impacts on U.S. total sugar production are slightly negative, but are positive in the long run. This decrease in production indicates that competitive U.S. sugar-producing regions increase production while less competitive U.S. regions decrease. Total U.S. sugar consumption increases 1.66% in the long run, after an initial loss in the short run due to a decrease in U.S. production and a small increase in exports. The negative short-run supply loss results from an immediate decrease of U.S. production, with export increases not large enough to cover the loss. Consumer surplus falls by less than 1% in the short run but increases 1.66% in the long run. In the long run, total supply of sugar has increased, placing downward pressure on the U.S. domestic price. The decreased price increases consumer sugar demand.

Table 5.25. Comparison percent changes of large-scale liberalization results

Result	Short-run	Long-run
Total Foreign Exports	2.620	10.880
Total U.S. Sugar Production	-0.440	0.230
U.S. Sugar Production Plus Exports	-0.020	1.660
Total Consumer Demand	-0.020	1.660

CHAPTER VI. SUMMARY AND CONCLUSIONS

Introduction

Chapter VI provides a summary of this thesis. The significance of the study's results as well as the limitations are discussed. Finally, suggestions for extensions of this research are proposed.

Thesis Summary

The goal of this study is to examine the potential effects of a Free Trade Area of the Americas (FTAA) agreement on the U.S. sugar industry. A linear programming model developed in GAMS is utilized to determine consumer surplus, domestic and foreign producer surplus, quantities consumed and produced, and prices under potential FTAA conditions. These results are tested under counterfactual scenarios which liberalize sugar trade mainly through large-scale quota increases from South and Central American countries. Mexico's impacts on the sugar industry are also combined with these alternative scenarios to determine the effects of NAFTA in 2008 when complete free trade exists with the United States. The model determines the optimal quantity of sugar traded under each counterfactual scenario. Welfare, production, exports, and prices are then compared.

Baseline results are calculated under the 2001 Tariff Rate Schedule (TRQ), including NAFTA provisions for Mexico. Under the baseline, foreign countries are subject to a high-duty, over-quota tariff of $0.1536 per pound, with the exception of Mexico which pays $0.1058 per pound. In the baseline, $0.10 per pound is multiplied by the entire quantity of tariff-free sugar imports to indicate sugar refinery rents under a restricted trade environment. U.S. supply equations are calibrated using 1998-2000 average production data and the 1998-2000 wholesale sugar beet price of $0.2486 per pound. Foreign supply equations are calibrated using 1998-2000 average exports of sugar to the United States and the 1998-2000 average world price of $0.0984 per pound. Demand equations for each consuming region are calibrated using 1998-2000 average domestic consumption, wholesale sugar price of $0.2486 per pound, and population.

Results

Results indicate that, as trade liberalization increases sugar exports to the United States under the potential Free Trade Area of the Americas (FTAA) agreement, the short-run impacts on U.S. producing regions and non-FTAA member countries are slightly negative. These negative impact levels increase with larger duty-free sugar import volumes. Consumers receive mixed results depending on the scenario, but remain mostly unchanged due to small changes in sugar supply in the short run. Foreign exporting countries gain from liberalizing trade in the short run, showing the largest positive returns when all countries experience unlimited, tariff-free access to the U.S. market.

Results under a long-run equilibrium show similar results for foreign exporters, with larger gains in exports, producer surpluses, and prices as compared to short-run results. Under long-run conditions and large-scale trade liberalization, U.S. sugar producers increase production from the baseline by less than 1%. U.S. consumers gain surplus and increase sugar consumption in the long run. Total U.S. sugar supply also increases under these long-run scenarios.

Conclusions

The results show small short-run impacts on the U.S. market due to production capacity constraints faced by foreign exporting countries. However, trade liberalization creates an incentive for foreign exporters to invest in their individual sugar industries. This investment improves sugar production ability, creating more elastic export supply. Long- run trade liberalization results report larger increases in exports versus short-run results. In the long run, U.S. consumers will be better off due to a lower sugar price from increased sugar supply. U.S. sugar production increases slightly in the long run, as more competitive producing regions replace production of those less efficient.

After an initial drop in sugarbeet production in the short run, the Red River Valley recovers from potential FTAA export effects of price depresssion. The Red River Valley holds the largest U.S. producer surplus in the baseline results and is the only sugarbeet producing region that increases production under large-scale, long-run trade liberalization. Price received and producer surplus decreased under these conditions. These results indicate that the Red River Valley will remain competitive even with larger sugar exports in the long run.

Limitations

This study has limitations that restrict actual potential effects of FTAA impacts on the U.S. sugar industry. One limitation of the study is that sugar-exporting countries are restricted by the model through U.S. sugar refinery capacity. A model constraint binds the amount of sugar production capabilities at each refinery, driving results that indicate refinery expansions are not taking place under more liberalized trade. Refinery expansion would likely occur in the event of an FTAA.

A second limitation of this thesis is that high fructose corn syrup (HFCS) substitutability issues are not addressed. HFCS issues in Mexico are very large considering NAFTA provisions. As Mexico increases HFCS imports from the United States for its beverage industry, more Mexican sugar will be available for export to the United States. This substitutability factor may play a role in South and Central American trade if an FTAA is in effect.

Several factors of the current sugar industry situation are not included in the model. Eliminated refined sugar imports are one of these factors. In the scope of this study, the small amounts of refined sugar TRQ imports do not play a large factor for industry changes. However, their existence does add to the U.S. domestic sugar supply. A second factor excluded from the model is the remaining sugar TRQ holding countries and their amount of exports to the United States. Admittedly, the remaining quotas are not as large in number as those that are incorporated in the model but are included in the total TRQ set by the U.S. Secretary of Agriculture every year. Determination of full effects of a FTAA would need to include these other imports. Finally, since actual FTAA rules and regulations are unknown, true effects cannot be determined.

Need for Further Study

This study is in need of continuation based on changing government policy regarding the Free Trade Area of the Americas agreement. The thesis is based on the current sugar program provisions, complete with a loan rate acting as a support system for U.S. domestic price. The TRQ system is also maintained in the study, applying tariffs on above-quota imports. In the event of an FTAA, government influences on agricultural trade may change. Agricultural trade policy may undergo changes by adjusting or eliminating both the sugar program and TRQ system. The addition of HFCS substitutability may also modify the optimal sugar quantity traded.

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APPENDIX A

Table A.1. Distance in miles from U.S. producing region to consuming region, denoted by city per region

Producing Region	New York City	Atlanta	Miami	New Orleans	Houston	St. Louis	Chicago	Minne-apolis	Billings	Seattle	Denver	San Francisco
Red River Valley	1452	1364	2031	1558	1405	861	648	234	606	1417	962	1894
Great Lakes	727	824	1491	1173	1501	592	319	736	1573	2384	1312	2485
Upper Great Plains	1893	1805	2472	1992	1839	1302	1089	675	269	1080	749	1557
Far West	2782	2090	2630	1791	1409	1815	2119	2057	1465	1446	1132	654

Source: Rand McNally Online (2001).

Table A.2. Distance in miles from U.S. producing region to refinery

Producing Region	Baltimore	Brooklyn	Chalmette	Crockett	Sugar Land	South Bay	Yonkers	Port Wentworth	Clewiston	Gramercy
Florida	1065	1266	841	3095	1186	0	1276	462	16	883
Louisiana	1239	1426	128	2180	271	962	1436	803	946	134
Texas	1769	1956	711	1980	307	1492	1966	1333	1436	670

Source: Rand McNally Online (2001).

Table A.3. Distance in miles from U.S. port to refinery

Port	Baltimore	Brooklyn	Chalmette	Crockett	Sugar Land	South Bay	Yonkers	Port Wentworth	Clewiston	Gramercy
New Orleans	1121	1308	8	2274	365	844	1319	685	828	43
San Francisco	2825	2915	2283	28	1923	3038	2913	2808	3022	2238
Baltimore	0	189	1118	2786	1470	1059	203	662	1054	1160
Jacksonville	757	946	543	2906	887	297	959	140	296	585

Source: Rand McNally Online (2001).

Table A.4. Distance in miles from refinery to consuming region, denoted by city per consuming region

Port	New York City	Atlanta	Miami	New Orleans	Houston	St. Louis	Chicago	Minne-apolis	Billings	Seattle	Denver	San Francisco
Baltimore	191	683	1106	1121	1445	830	702	1117	1955	2771	1701	2825
Brooklyn	6	872	1294	1310	1633	747	795	1210	2048	2864	1782	2918
Chalmette	1299	484	863	9	354	682	932	1307	1947	2724	1403	2282
Crockett	2888	2557	3120	2278	1930	2083	2113	2025	1155	780	1251	28
Sugar Land	1645	830	1208	366	21	886	1108	1245	1681	2458	1137	1921
South Bay	1260	644	81	844	1110	1202	1359	1772	2527	3344	2053	3094
Yonkers	18	887	1310	1317	1641	981	801	1216	2054	2870	1788	2924
Port Wentworth	806	251	498	685	1009	805	951	1380	2129	2946	1655	2912
Clewiston	1238	628	97	828	1113	1148	1343	1717	2511	3328	1997	3078
Gramercy	1342	526	905	43	313	668	918	1292	1906	2683	1362	2239

Source: Rand McNally Online (2001).

Table A.5. Distance in nautical miles from exporting country to U.S. port

Region	New Orleans	San Francisco	Baltimore	Jacksonville
Mexico	0	4738	1915	1322
Cuba	797	4310	1110	532
Caribbean	1559	4550	1850	1175
SA1	5066	8435	4839	4741
SA2	6171	7578	5914	5809
SA3	4314	2487	2745	2383
CA1	1935	2625	2620	2257
CA2	898	2325	2895	2447
South Africa	7672	10228	6926	6855
Australia	8089	6200	9623	9233
Philippines	8986	6250	11767	10907

Source: Maritime Chain Online (2000) and Partnership Shipping Portal Online (1999).

Table A.6. Transportation cost in $/1000 tons for raw sugar ocean transport from foreign country to U.S. port

Region	Baltimore	New Orleans	Jacksonville	San Francisco
Mexico	$ 18,635	$ 16,603	$ 17,556	$ 23,770
Cuba	$ 17,171	$ 16,601	$ 16,119	$ 22,991
Caribbean	$ 18,517	$ 17,987	$ 17,289	$ 23,428
SA1	$ 23,954	$ 24,367	$ 23,775	$ 30,495
SA2	$ 25,909	$ 26,377	$ 25,718	$ 28,936
SA3	$ 20,145	$ 22,999	$ 19,486	$ 19,675
CA1	$ 19,917	$ 18,671	$ 19,257	$ 19,926
CA2	$ 20,417	$ 16,785	$ 19,603	$ 19,381
South Africa	$ 27,750	$ 29,107	$ 27,621	$ 33,756
Australia	$ 32,656	$ 29,865	$ 31,946	$ 26,429
Philippines	$ 36,556	$ 31,497	$ 34,991	$ 26,520

Source: Sample Oceanic rates from American Crystal Sugar Company (2002).

Table A.7. Transportation cost by rail in $/1000 tons for raw sugar from U.S. producing region to refinery

Producing Region	Baltimore	Brooklyn	Chalmette	Crockett	Sugar Land	South Bay	Yonkers	Port Wentworth	Clewiston	Gramercy
Florida	$ 26,434	$ 28,518	$ 24,111	$ 47,481	$ 27,688	$ -	$ 28,621	$ 20,182	$ -	$ 24,547
Louisiana	$ 28,238	$ 30,176	$ 16,719	$ 37,994	$ 18,201	$ 25,366	$ 30,280	$ 23,717	$ 25,200	$ 16,781
Texas	$ 33,733	$ 35,672	$ 22,763	$ 35,920	$ 18,575	$ 30,861	$ 35,775	$ 29,212	$ 30,280	$ 22,338

Source: Burlington Northern Santa Fe Railroad (2002).

Table A.8. Transportation cost by rail in $/1000 tons for raw sugar from port to refinery

Port	Baltimore	Brooklyn	Chalmette	Crockett	Sugar Land	South Bay	Yonkers	Port Wentworth	Clewiston	Gramercy
New Orleans	$ 27,014	$ 28,953	$ 15,475	$ 38,969	$ 19,176	$ 24,142	$ 29,067	$ 22,494	$ 23,976	$ 15,838
San Francisco	$ 44,681	$ 45,614	$ 39,062	$ 15,682	$ 35,329	$ 46,890	$ 45,594	$ 44,505	$ 46,724	$ 38,595
Baltimore	$ 15,392	$ 17,351	$ 26,983	$ 44,277	$ 30,633	$ 26,371	$ 17,496	$ 22,255	$ 26,320	$ 27,419
Jacksonville	$ 23,240	$ 25,200	$ 21,022	$ 45,521	$ 24,588	$ 18,471	$ 25,335	$ 16,843	$ 18,461	$ 21,457

Source: Burlington Northern Santa Fe Railroad (2002).

Table A.9. Transportation cost by rail in $/1000 tons for refined sugar from producing region to consuming region, denoted by city per consuming region

Producing Region	New York City	Atlanta	Miami	New Orleans	Houston	St. Louis	Chicago	Minne -apolis	Billings	Seattle	Denver	San Francisco
Red River Valley	$ 57,156	$54,958	$ 71,613	$59,802	$55,982	$42,398	$37,080	$26,742	$36,031	$ 56,282	$ 44,920	$ 68,192
Great Lakes	$ 39,052	$41,474	$ 58,129	$50,189	$58,379	$35,681	$28,865	$39,277	$60,177	$ 80,428	$ 53,660	$ 82,950
Upper Great Plains	$ 68,167	$65,970	$ 82,625	$70,639	$66,819	$53,410	$48,092	$37,754	$27,616	$ 47,867	$ 39,602	$ 59,777
Far West	$ 90,366	$73,087	$ 86,570	$65,620	$56,082	$66,220	$73,811	$72,262	$57,480	$ 57,006	$ 49,165	$ 37,230

Source: Burlington Northern Santa Fe Railroad (2002).

Table A.10. Transportation cost by rail in $/1000 ton for refined sugar from refinery to consuming region, denoted by city per consuming region

Refinery	New York City	Atlanta	Miami	New Orleans	Houston	St. Louis	Chicago	Minne -apolis	Billings	Seattle	Denver	San Francisco
Baltimore	$ 25,668	$37,954	$ 48,516	$48,891	$56,981	$41,624	$38,428	$48,791	$69,716	$ 90,091	$ 63,373	$ 91,439
Brooklyn	$ 21,049	$42,673	$ 53,210	$53,610	$61,675	$39,552	$40,750	$51,113	$72,038	$ 92,413	$ 65,396	$ 93,762
Chalmette	$ 53,335	$32,985	$ 42,448	$21,124	$29,739	$37,929	$44,171	$53,535	$69,516	$ 88,917	$ 55,932	$ 77,881
Crockett	$ 93,013	$84,747	$ 98,806	$77,781	$69,091	$72,912	$73,661	$71,463	$49,740	$ 40,376	$ 52,137	$ 21,598
Sugar Land	$ 61,975	$41,624	$ 51,063	$30,038	$21,424	$43,023	$48,566	$51,987	$62,874	$ 82,275	$ 49,290	$ 68,867
South Bay	$ 52,361	$36,980	$ 22,922	$41,974	$48,616	$50,913	$54,833	$65,146	$83,998	$104,399	$ 72,163	$ 98,156
Yonkers	$ 21,349	$43,048	$ 53,610	$53,785	$61,875	$45,395	$40,900	$51,263	$72,188	$ 92,563	$ 65,546	$ 93,911
Port Wentworth	$ 41,025	$27,167	$ 33,334	$38,004	$46,094	$41,000	$44,646	$55,358	$74,060	$ 94,461	$ 62,225	$ 93,612
Clewiston	$ 51,812	$36,580	$ 23,321	$41,574	$48,691	$49,565	$54,434	$63,773	$83,599	$103,999	$ 70,764	$ 97,757
Gramercy	$ 54,409	$34,033	$ 43,497	$21,973	$28,715	$37,579	$43,822	$53,160	$68,492	$ 87,894	$ 54,908	$ 76,807

Source: Burlington Northern Santa Fe Railroad (2002).

APPENDIX B

Table B.1. Example of FTAA sugar model written in GAMS

```
OPTION limrow=0;
OPTION limcol=0;


SETS
 region /us,mexico,cuba,caribbean,sa1,sa2,sa3,ca1,ca2,safrica,aust,
        phil,rrv,gl,ugp,fw,fl,la,tx/
 m(region) /mexico,cuba,caribbean,sa1,sa2,sa3,ca1,ca2,safrica,aust,phil/
 j(region) us producing regions /rrv,gl,ugp,fw,fl,la,tx/
 i us consuming regions /ny,alt,miami,no,houston,stl,chi,minn,bill,seattle,den,sanfran/
 prodttl /beet,cane,product,recov,refine,calibrate,pprice,pint,pslope/
 consttl /pop,cons,totcons,demelas,cprice,cint,cslope/
 h  domestic refineries /balt,brook,chal,crock,sugland,sbay,yonkers,pwent,clew,gram/
 costs /convh, pc, daymelt/
 mtrqs /quota/
**data here is both raw and refined sugars but measured in raw value
p US ports /blt, newo, jack, sfran/
 sugar /raw, refined/
tsugar/tar,no-tar/
;
ALIAS (m,m1), (j,j1), (i,i1), (h,h1), (p,p1);
TABLE demdata(i,consttl) parameters for us refined sugar demand
$ONDELIM
$INCLUDE c:\melissa\demand.csv
$OFFDELIM
DISPLAY demdata;

TABLE ussupdata(j,prodttl) parameters for us beet and cane supply
$ONDELIM
$INCLUDE c:\melissa\ussup.csv
$OFFDELIM
DISPLAY ussupdata;

TABLE forsupdata(m,prodttl) parameters for foreign supply
$ONDELIM
$INCLUDE c:\melissa\foreignsup.csv
$OFFDELIM
DISPLAY forsupdata;

TABLE jtoidata (j,i) transportation rates in cents per mile
$ONDELIM
$INCLUDE c:\melissa\jtoi.csv
$OFFDELIM
DISPLAY jtoidata;
```

```
TABLE mtopdata (m,p) transportation rates in cents per mile
$ONDELIM
$INCLUDE c:\melissa\mtop.csv
$OFFDELIM
DISPLAY mtopdata;

TABLE ptohdata (p,h) mileage from us port p to refinery h
$ONDELIM
$INCLUDE c:\melissa\ptoh.csv
$OFFDELIM
DISPLAY ptohdata;

TABLE htoidata (h,i) transportation rates in cents per mile
$ONDELIM
$INCLUDE c:\melissa\htoi.csv
$OFFDELIM
DISPLAY htoidata;

TABLE jtohdata (j,h) mileage from us producing region j to refinery h
$ONDELIM
$INCLUDE c:\melissa\jtoh.csv
$OFFDELIM
DISPLAY jtohdata;

TABLE hcostsdata(h,costs) costs incurred at U.S. refineries
$ONDELIM
$INCLUDE c:\melissa\hcosts.csv
$OFFDELIM
DISPLAY hcostsdata;

TABLE trqdata(m,mtrqs) 2002 trq's imposed on foreign countries m
$ONDELIM
$INCLUDE c:\melissa\trq.csv
$OFFDELIM
DISPLAY trqdata;

PARAMETERS
proccost(h) processing costs at refinery h
a(i)  refined sugar demand intercept for consuming region i
b(i)  refined sugar demand price coefficient for consuming region i
d(region,sugar) intercept of sugar supply equation by region
e(region,sugar) price coefficient of sugar supply equation by region
conv(h) conversion rate at refinery h from raw to refined
convm(m) conversion rate for sugar from country m
```

```
itransj(j,i) transportation cost to i from j
itransp(p,i) transportation cost from port p to consuming region i
mtransp(m,p) transportation cost from country m to port p
ptransh(p,h) transportation cost from p to h
htransi(h,i) transportation cost from h to i
jtransh(j,h) transportation cost from j to h
trqsm(m) quotas imposed on country m by the U.S.
melt(h) daily melting capacity of U.S. sugar refineries
tariff(m) tariffs of above-quota imports
handle(p) handling costs at port incurred by country m
;
melt(h) = hcostsdata(h,'daymelt')*365;
tariff(m)= 307200;
tariff('mexico')= 211600;
handle(p)= 13944;
trqsm(m) = trqdata(m,'quota');
proccost(h) = hcostsdata(h,'pc');
conv(h) = hcostsdata(h,'convh') ;

PARAMETERS
 calisup(region,sugar)
 calidem(i)
 totsup
 totdem
;

totsup = SUM(j,ussupdata(j,'refine')) + SUM(m,forsupdata(m,'refine'));
totdem = SUM(i,demdata(i,'totcons'));
demdata(i,'totcons') = (totsup)*(demdata(i,'totcons')/totdem);
b(i) = demdata(i,'demelas')*demdata(i,'totcons')/demdata(i,'cprice');
a(i) = demdata(i,'totcons') - b(i)*demdata(i,'cprice');
calidem(i) = a(i) + b(i)*demdata(i,'cprice');
totdem= SUM(i,calidem(i));

e(j,'refined') = ussupdata(j,'cane')*ussupdata(j,'refine')/ussupdata(j,'pprice');
d(j,'refined') = ussupdata(j,'refine')-e(j,'refined')*ussupdata(j,'pprice');
LOOP(j$ussupdata(j,'beet'),
 e(j,'refined') = ussupdata(j,'beet')*ussupdata(j,'refine')/ussupdata(j,'pprice');
 d(j,'refined') = ussupdata(j,'refine')-e(j,'refined')*ussupdata(j,'pprice');
);
e(m,'refined') = forsupdata(m,'cane')*forsupdata(m,'refine')/forsupdata(m,'pprice');
d(m,'refined') = forsupdata(m,'refine')-e(m,'refined')*forsupdata(m,'pprice');

DISPLAY a,b,d,e, calidem;
```

```
calisup(m,'refined') = d(m,'refined')+e(m,'refined')*forsupdata(m,'pprice');
calisup(j,'refined') =d(j,'refined')+e(j,'refined')*ussupdata(j,'pprice');
totsup = sum((region,sugar)$e(region,sugar), calisup(region,sugar));
DISPLAY totsup,totdem;

POSITIVE VARIABLES
 trxraw(m,p,h,i) raw sugar product from foreign country m to us port p raw sugar
 trjraw(j,h,i) raw sugar product from us producing region j to refinery h
 trjref(j,i) refined sugar product from us producing region j to consuming region i
 cons(i) consumption of refined sugar by region i
 xprdraw(m) production of raw sugar by exporter m
 xprdref(m) production of refined sugar by exporter m
 usprdraw(j) production of raw sugar by us producing region j
 usprdref(j) production of refined sugar by us producing region j
 xsugar(tsugar,m,p,h,i) imports of sugar from m with and without tarriffs
;

VARIABLES
surplus
;

EQUATIONS
 totxraw(m)
 totusraw (j)
 totusref(j)
 obj
 quotas(m) imposed trqs on countries m
 refincap(h) refinery capacity max
 xtot(m) total quantity of exports with and without tariffs
 convx(m) converts raw to refined
 totsequal(i)
 totx(m)
 forsup(m,p,h,i)
*other equation names here
;
xprdref.l(m) = forsupdata(m,'calibrate');
xprdraw.l(m) = xprdref.l(m)*1.07;
usprdref.l(j) = ussupdata(j,'calibrate');
usprdraw.l(j) = usprdref.l(j)*1.07;

totsequal(i).. SUM((j,h),trjraw(j,h,i)/1.07)+SUM(j,trjref(j,i))+
          SUM((m,p,h),trxraw(m,p,h,i)/1.07)=E=cons(i);
convx(m).. xprdref(m) =E= xprdraw(m)/1.07;
totxraw(m).. xprdraw(m) =E= SUM((p,h,i),trxraw(m,p,h,i));
```

```
xprdraw.fx('cuba')=0;
xprdref.fx('cuba')=0;
totusraw(j).. usprdraw(j) =E= SUM((h,i),trjraw(j,h,i));
totusref(j).. usprdref(j) =E= SUM(i,trjref(j,i))
                    +usprdraw(j)/1.07;
totx(m)..  xprdraw(m) =E= SUM((p,h,i),trxraw(m,p,h,i));
**Demand constraints
xtot(m).. xprdraw(m) =E= SUM((p,h,i),xsugar('no-tar',m,p,h,i) + xsugar('tar',m,p,h,i));
forsup(m,p,h,i).. trxraw(m,p,h,i) =E= SUM(tsugar,xsugar(tsugar,m,p,h,i));
quotas(m).. SUM((p,h,i),xsugar('no-tar',m,p,h,i)) =L= trqsm(m);
refincap(h).. SUM((j,i),trjraw(j,h,i))+SUM((m,p,i),trxraw(m,p,h,i))
            =L= melt(h);
cons.up(i)= a(i);
usprdraw.l(j) = ussupdata(j,'cane');
LOOP(j$ussupdata(j,'beet'),
 usprdraw.fx(j)=0;
);
LOOP(j$ussupdata(j,'cane'),
 usprdraw.l(j) = ussupdata(j,'cane');
 trjref.fx(j,i) = 0;
);
usprdref.l(j) = ussupdata(j,'refine');
cons.lo(i) = demdata(i,'totcons')*0.1;
usprdref.lo(j) = d(j,'refined');
xprdref.lo(m) = d(m,'refined');

obj.. surplus =E= SUM(i,
             POWER(cons(i),2)/(2*b(i))
             -a(i)*cons(i)/b(i)
            )
-SUM(j$e(j,'refined'),
   POWER(usprdref(j),2)/(2*e(j,'refined'))
   -d(j,'refined')*usprdref(j)/e(j,'refined')
   +POWER(d(j,'refined'),2)/(2*e(j,'refined'))
 )
-SUM(m$e(m,'refined'),
      +POWER(xprdref(m),2)/(2*e(m,'refined'))
      -d(m,'refined')*xprdref(m)/e(m,'refined')
      +POWER(d(m,'refined'),2)/(2*e(m,'refined'))
 )
-SUM((j,i),jtoidata(j,i)*trjref(j,i))
-SUM((m,p,h,i),(mtopdata(m,p)+handle(p)+ptohdata(p,h)
          + proccost(h) + htoidata(h,i)/1.07)*trxraw(m,p,h,i))
-SUM((j,h,i),(jtohdata(j,h) + proccost(h)+htoidata(h,i)/1.07)* trjraw(j,h,i))
```

Table B.1. (Continued)

```
-SUM((m,p,h,i),xsugar('tar',m,p,h,i)*tariff(m))
-SUM((m,p,h,i),xsugar('no-tar',m,p,h,i)/1.07* 200000)
;

MODEL sugar1 /ALL/;
SOLVE sugar1 USING NLP MAXIMIZING surplus;
PARAMETERS
 cs(i)
 ps(region)
 totwel
 totps
 totcs
 pricec(i)
 pricexb(m,p,h,i)
 pricexa(m,p,h,i)
 priceusji(j,i)
 priceusjhi(j,h,i)
;
pricec(i) = (cons.l(i)-a(i))/b(i);
LOOP((m,p,h,i)$xsugar.l('no-tar',m,p,h,i),
 pricexb(m,p,h,i) = (pricec(i)
                -mtopdata(m,p)*1.07
                -handle(p)*1.07
                -ptohdata(p,h)*1.07
                -proccost(h)*1.07
                -htoidata(h,i)
                -200000)/2000000;
);
LOOP((m,p,h,i)$xsugar.l('tar',m,p,h,i),
 pricexa(m,p,h,i) = (pricec(i)
                -mtopdata(m,p)*1.07
                -handle(p)*1.07
                -ptohdata(p,h)*1.07
                -proccost(h)*1.07
                -htoidata(h,i)
                -tariff(m)*1.07)/2000000;
);
LOOP((j,i)$trjref.l(j,i),
 priceusji(j,i) = (pricec(i)-jtoidata(j,i))/2000000;
);
LOOP((j,h,i)$trjraw.l(j,h,i),
 priceusjhi(j,h,i) = (pricec(i)
                 -jtohdata(j,h)*1.07
                 -proccost(h)*1.07
```

```
         -htoidata(h,i))/2000000;
);
pricec(i) = pricec(i)/2000000;
DISPLAY pricec,pricexb,pricexa,priceusji,priceusjhi;
pricec(i) = pricec(i)*2000000;
pricexb(m,p,h,i) = pricexb(m,p,h,i)*2000000;
pricexa(m,p,h,i) = pricexa(m,p,h,i)*2000000;
priceusjhi(j,h,i) = priceusjhi(j,h,i)*2000000;
priceusji(j,i) = priceusji(j,i)*2000000;
cs(i) = cons.l(i)/2*(-a(i)/b(i)-pricec(i));
e('cuba','refined') = 1;
ps(j) = SUM((h,i)$trjraw.l(j,h,i),
        trjraw.l(j,h,i)/1.07*priceusjhi(j,h,i)
       )
      +SUM(i$trjref.l(j,i),
         trjref.l(j,i)*priceusji(j,i)
       )
       - POWER(usprdref.l(j),2)/(2*e(j,'refined'))
        +d(j,'refined')*usprdref.l(j)/e(j,'refined')
        -POWER(d(j,'refined'),2)/(2*e(j,'refined'))
;
ps(m) = SUM((p,h,i)$trxraw.l(m,p,h,i),
           xsugar.l('tar',m,p,h,i)/1.07*pricexa(m,p,h,i)
          + xsugar.l('no-tar',m,p,h,i)/1.07*pricexb(m,p,h,i)
         )
         -POWER(xprdref.l(m),2)/(2*e(m,'refined'))
         +d(m,'refined')*xprdref.l(m)/e(m,'refined')
         -POWER(d(m,'refined'),2)/(2*e(m,'refined'))
;
totcs = SUM(i,cs(i));
totps = SUM(region,ps(region));
totwel = totcs + totps;
DISPLAY cs,ps,totcs,totps,totwel,surplus.l;

PARAMETERS
 usprice
 worldprice      non US sugar price
 avgpr(region)
 refprod(region) refined sugar production per region
avgcprice
consump(i)
txprod
tusprod
txps
```

Table B.1. (Continued)

```
tps
tusps
comprod
tcons
tcs
;
xprdref.l('cuba') = 1;
avgpr(m) = SUM((p,h,i)$trxraw.l(m,p,h,i),
            xsugar.l('tar',m,p,h,i)/1.07*pricexa(m,p,h,i)
          + xsugar.l('no-tar',m,p,h,i)/1.07*pricexb(m,p,h,i)
         )/xprdref.l(m)/2000000;
worldprice = SUM(m$(ORD(m) NE 2),avgpr(m)*xprdref.l(m))
            /SUM(m$(ORD(m) NE 2),xprdref.l(m));
avgpr(j) =(SUM((h,i)$trjraw.l(j,h,i),
         trjraw.l(j,h,i)/1.07*priceusjhi(j,h,i)
        )
       +SUM(i$trjref.l(j,i),
         trjref.l(j,i)*priceusji(j,i)
        ))/usprdref.l(j)/2000000;
usprice = SUM(j,avgpr(j)*usprdref.l(j))/SUM(j,usprdref.l(j));
avgcprice= SUM(i,pricec(i)*cons.l(i))/SUM(i,cons.l(i));
refprod(m) = xprdref.l(m);
refprod(j) = usprdref.l(j);
consump(i) = cons.l(i);
xprdref.l('cuba') =0;
txprod =SUM(m,xprdref.l(m));
tusprod =SUM(j,usprdref.l(j));
txps =SUM(m,ps(m));
tusps =SUM(j,ps(j));
tps = txps + tusps;
tcons = SUM(i,cons.l(i));
tcs = SUM(i,cs(i));
comprod = SUM(j,usprdref.l(j))+SUM(m,xprdref.l(m));
FILE producer1 /c:\melissa\prod1.txt/;
PUT producer1;
PUT "Region         Surplus           Exports        Price Received"/;
LOOP(region$(ORD(region) GT 1),
 PUT region.tl, ps(region):15:2, refprod(region):15:4, avgpr(region):15:4 /;
);
 PUT "M totals   ", txps:15:2, txprod:15:2, worldprice:15:4/;
 PUT "US totals  ", tusps:15:2, tusprod:15:2, usprice:15:4/;
 PUT "Totals     ", tps: 15:2, comprod:15:2;
pricec(i) = pricec(i)/2000000;
avgcprice = avgcprice/2000000;
```

Table B.1. (Continued)

```
FILE consumer1 /c:\melissa\cons1.txt/;
PUT consumer1;
PUT "Region        Surplus            Demand         Price Paid"/;
LOOP(i,
 PUT i.tl, cs(i):15:2, cons.l(i):15:2, pricec(i):15:4 /;
);
PUT "Totals      ", tcs:15:2, tcons:15:2, avgcprice:15:4;
DISPLAY avgpr;
pricec(i) = pricec(i)*2000000;
avgcprice = avgcprice*2000000;
*now change quotas and tariffs then resolve

trqsm('mexico') = 500;
tariff('mexico') = 0;
***Melissa do you need to keep the 10 cent processor profits
***If so keep lines below otherwise delete
LOOP(m$(tariff(m) EQ 0),
 tariff(m) = 200000;
);
*** to here
SOLVE sugar1 USING NLP MAXIMIZING surplus;
pricec(i) = (cons.l(i)-a(i))/b(i);
LOOP((m,p,h,i)$xsugar.l('no-tar',m,p,h,i),
 pricexb(m,p,h,i) = (pricec(i)
                -mtopdata(m,p)*1.07
                -handle(p)*1.07
                -ptohdata(p,h)*1.07
                -proccost(h)*1.07
                -htoidata(h,i)
                -200000)/2000000;
);
LOOP((m,p,h,i)$xsugar.l('tar',m,p,h,i),
 pricexa(m,p,h,i) = (pricec(i)
                -mtopdata(m,p)*1.07
                -handle(p)*1.07
                -ptohdata(p,h)*1.07
                -proccost(h)*1.07
                -htoidata(h,i)
                -tariff(m)*1.07)/2000000;
);
LOOP((j,i)$trjref.l(j,i),
 priceusji(j,i) = (pricec(i)-jtoidata(j,i))/2000000;
);
LOOP((j,h,i)$trjraw.l(j,h,i),
```

```
 priceusjhi(j,h,i) = (pricec(i)
                 -jtohdata(j,h)*1.07
                 -proccost(h)*1.07
                 -htoidata(h,i))/2000000;
);
pricec(i) = pricec(i)/2000000;
DISPLAY pricec,pricexb,pricexa,priceusji,priceusjhi;
pricec(i) = pricec(i)*2000000;
pricexb(m,p,h,i) = pricexb(m,p,h,i)*2000000;
pricexa(m,p,h,i) = pricexa(m,p,h,i)*2000000;
priceusjhi(j,h,i) = priceusjhi(j,h,i)*2000000;
priceusji(j,i) = priceusji(j,i)*2000000;
ps(j) = ((SUM((h,i)$trjraw.l(j,h,i),
        trjraw.l(j,h,i)/1.07*priceusjhi(j,h,i)
       )
      +SUM(i$trjref.l(j,i),
         trjref.l(j,i)*priceusji(j,i)
       )
       - POWER(usprdref.l(j),2)/(2*e(j,'refined'))
        +d(j,'refined')*usprdref.l(j)/e(j,'refined')
        -POWER(d(j,'refined'),2)/(2*e(j,'refined'))
       )-ps(j))/ps(j)*100;
ps('cuba') = 1;
ps(m) = ((SUM((p,h,i)$trxraw.l(m,p,h,i),
            xsugar.l('tar',m,p,h,i)/1.07*pricexa(m,p,h,i)
          + xsugar.l('no-tar',m,p,h,i)/1.07*pricexb(m,p,h,i)
         )
         -POWER(xprdref.l(m),2)/(2*e(m,'refined'))
         +d(m,'refined')*xprdref.l(m)/e(m,'refined')
         -POWER(d(m,'refined'),2)/(2*e(m,'refined'))
         )-ps(m))/ps(m)*100;
;
pricec(i) = (((cons.l(i)-a(i))/b(i))
            -pricec(i))/pricec(i)*100;
xprdref.l('cuba') = 1;
avgpr('cuba') = 1;
avgpr(m) = ((SUM((p,h,i)$trxraw.l(m,p,h,i),
            xsugar.l('tar',m,p,h,i)/1.07*pricexa(m,p,h,i)
          + xsugar.l('no-tar',m,p,h,i)/1.07*pricexb(m,p,h,i)
         )/xprdref.l(m))/2000000-avgpr(m))/avgpr(m)*100;

avgpr(j) =(((SUM((h,i)$trjraw.l(j,h,i),
        trjraw.l(j,h,i)/1.07*priceusjhi(j,h,i)
       )
```

```
       +SUM(i$trjref.l(j,i),
          trjref.l(j,i)*priceusji(j,i)
        ))/usprdref.l(j)/2000000)-avgpr(j))/avgpr(j)*100;
refprod(m) = (xprdref.l(m)-refprod(m))/refprod(m)*100;
refprod(j) = (usprdref.l(j)-refprod(j))/refprod(j)*100;
consump(i) = (cons.l(i)-consump(i))/consump(i)*100;
DISPLAY ps,cs, avgpr, pricec, refprod, consump;
refprod('cuba') = 0;
xprdref.l('cuba') = 0;
txprod = (SUM(m,xprdref.l(m))-txprod)/txprod*100;
tusprod =(SUM(j,usprdref.l(j))-tusprod)/tusprod*100;
ps('cuba') = 0;
txps =(SUM(m,(SUM((p,h,i)$trxraw.l(m,p,h,i),
            xsugar.l('tar',m,p,h,i)/1.07*pricexa(m,p,h,i)
          + xsugar.l('no-tar',m,p,h,i)/1.07*pricexb(m,p,h,i)
          )
          -POWER(xprdref.l(m),2)/(2*e(m,'refined'))
          +d(m,'refined')*xprdref.l(m)/e(m,'refined')
          -POWER(d(m,'refined'),2)/(2*e(m,'refined'))
          ))-txps)/txps*100;
tusps =(SUM(j,(SUM((h,i)$trjraw.l(j,h,i),
         trjraw.l(j,h,i)/1.07*priceusjhi(j,h,i)
        )
       +SUM(i$trjref.l(j,i),
          trjref.l(j,i)*priceusji(j,i)
        )
        - POWER(usprdref.l(j),2)/(2*e(j,'refined'))
         +d(j,'refined')*usprdref.l(j)/e(j,'refined')
         -POWER(d(j,'refined'),2)/(2*e(j,'refined'))
        ))-tusps)/tusps*100;
tps =  (((SUM(j,(SUM((h,i)$trjraw.l(j,h,i),
         trjraw.l(j,h,i)/1.07*priceusjhi(j,h,i)
        )
       +SUM(i$trjref.l(j,i),
          trjref.l(j,i)*priceusji(j,i)
        )
        - POWER(usprdref.l(j),2)/(2*e(j,'refined'))
         +d(j,'refined')*usprdref.l(j)/e(j,'refined')
         -POWER(d(j,'refined'),2)/(2*e(j,'refined'))
        )))
       +(SUM(m,(SUM((p,h,i)$trxraw.l(m,p,h,i),
            xsugar.l('tar',m,p,h,i)/1.07*pricexa(m,p,h,i)
          + xsugar.l('no-tar',m,p,h,i)/1.07*pricexb(m,p,h,i)
          )
```

```
          -POWER(xprdref.l(m),2)/(2*e(m,'refined'))
          +d(m,'refined')*xprdref.l(m)/e(m,'refined')
          -POWER(d(m,'refined'),2)/(2*e(m,'refined'))
          )))
         )-tps)/tps*100;
tcons = (SUM(i,cons.l(i))-tcons)/tcons*100;
tcs = (SUM(i,(cons.l(i)/2*(-a(i)/b(i)-((cons.l(i)-a(i))/b(i)))))-tcs)/tcs*100;
avgcprice= (SUM(i,(cons.l(i)-a(i))/b(i)*cons.l(i))
             / SUM(i,cons.l(i))
             -avgcprice)/avgcprice*100/2000000;
comprod = (SUM(j,usprdref.l(j))+SUM(m,xprdref.l(m))-comprod)/comprod*100;
cs(i) = ((cons.l(i)/2*(-a(i)/b(i)-((cons.l(i)-a(i))/b(i)))
           )-cs(i))/cs(i)*100 ;
avgpr('cuba') = 0;
pricec(i) = pricec(i)/2000000;
avgcprice = avgcprice/2000000;
worldprice = ((SUM(m$(ORD(m) NE 2),
              SUM((p,h,i)$trxraw.l(m,p,h,i),
               xsugar.l('tar',m,p,h,i)/1.07*pricexa(m,p,h,i)
             + xsugar.l('no-tar',m,p,h,i)/1.07*pricexb(m,p,h,i)
             )) /SUM(m$(ORD(m) NE 2),xprdref.l(m))/2000000)
               -worldprice)/worldprice*100;
usprice = ((SUM(j,(((SUM((h,i)$trjraw.l(j,h,i),
         trjraw.l(j,h,i)/1.07*priceusjhi(j,h,i)
        )
       +SUM(i$trjref.l(j,i),
          trjref.l(j,i)*priceusji(j,i)
        ))/usprdref.l(j)/2000000))
             *usprdref.l(j))/SUM(j,usprdref.l(j)))-usprice)/usprice*100;
FILE producer2 /c:\melissa\prod2.txt/;
PUT producer2;
PUT "Region            Surplus      Exports      Price Received"/;
LOOP(region$(ORD(region) GT 1),
 PUT region.tl, ps(region):15:2, refprod(region):15:4, avgpr(region):15:4 /;
);
 PUT "M totals   ", txps:15:2, txprod:15:2, worldprice:15:4/;
 PUT "US totals  ", tusps:15:2, tusprod:15:2, usprice:15:4/;
 PUT "Totals     ", tps: 15:2, comprod:15:2;

FILE consumer2 /c:\melissa\cons2.txt/;
PUT consumer2;
PUT "Region            Surplus       Demand      Price Paid"/;
LOOP(i,
 PUT i.tl, cs(i):15:2, consump(i):15:2, pricec(i):15:4 /;
```

Table B.1. (Continued)

```
);
PUT "Totals      ", tcs:15:2, tcons:15:2, avgcprice:15:4;
```