Analysis of the U.S.-Mexico sugar trade
- 10 years of NAFTA regime and 10 years from now

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Abstract
The U.S.– Mexico sugar trade was examined, paying a close attention to the provisions of North American Free Trade Agreement (NAFTA) and the circumstances surrounding the industries of the two countries. Quantitative analyses provided the outlook of the future sugar market and shed light on the political implications.

Key words: NAFTA, High Fructose Corn Syrup, quota

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Introduction

The North American Free Trade Agreement (NAFTA) marked its 10th anniversary at the beginning of 2004. Sugar and High Fructose Corn Syrup (HFCS) are a pair of key commodities that been affected by a freer trade environment among member economies. Of the three routes of trade flow, U.S.– Mexico, U.S.-Canada and Mexico- Canada, both sugar and HFCS trade between the U.S. and Mexico has been drawing the most attention because of the magnitude of economic and political impacts on these economies. When trading sugar with the United States, the Mexican sugar industry faces two counteracting conditions under the NAFTA regime: increased access to the U.S. market which would facilitate increased sugar exports at favorable prices; and the pressure of increased imports of HFCS from the United States which has been gaining an increasing share of Mexico's sweetener market since 1994. Under the provisions of NAFTA, both an over-quota tariff for Mexican sugar which enters into the United States and a tariff on exported HFCS which enters the Mexican market are regulated in such a way that both tariffs will be reduced to zero by 2008 and 2004, respectively. In addition to the rules of the tariffs, Mexican sugar is subject to U.S. import quota allocations. Mexico is allowed to access two kinds of quotas, depending on Mexico's domestic balance in the sweetener market: if Mexico's sugar production exceeds its sweetener consumption (the sum of sugar and HFCS consumption in two consecutive years -"net surplus sweetener producer status"), Mexico receives 25,000 MT of sugar import quota; and if not, Mexico receives 7,258 MT of quota. Additionally beginning in 2000, the sugar import quota expands from 25,000 MT to 250,000 MT. In 2008 when all the restrictions are lifted, Mexico will have free and unlimited access to the U.S. sugar market.

In Mexico, the sugar industry has played an important role in the economy and the politics of the country. In spite of experiencing drastic economic and political changes including NAFTA, devaluation, privatization of the sugar cane processing industry in the 1990s, and several changes in the policy regime, sugar production has shown steady expansion over the past 10 years: Mexican sugar production expanded from 3.2 million MT in 1990 to 4.7 million MT in 2000 (COAAZUCAR, 2003a). A significant amount of surplus sugar destined to export has been generated since 1995, ranging from 200,000 MT in 1995 to over 1.1 million MT in 1998 (COAAZUCAR, 2003a). These records may appear favorable; however, Mexico stood to benefit little from NAFTA. From 1996 through 1999 Mexico successfully received a 25,000 MT import quota as a result of attaining a net surplus producer status, yet it did not enjoy the expanded quota (250,000 MT) from 2000 through 2002 (USDA, 2003a) because Mexico's production fell short relative to its sweetener consumption. This indicates that Mexico missed the opportunity to export sugar under-quota even though it generated a significant surplus. Combined with a slump in production that occurred in 1999 and 2000, the Mexican sugar industry underwent an economic crisis. In September 2001, the Mexican government expropriated 27 of 60 Mexico's functioning sugar mills in order to maintain the industry (USDA, 2002b). The circumstances surrounding the sugar industry remain unfavorable, consequently there has been little benefit to the Mexican sugar industry resulting from NAFTA.

The U.S. sugar market, where a large quantity of sugar is traded by a large number of sellers, has maintained commodity balance by assigning import quotas to foreign sellers. As a result of GATT, the United states committed to accept a minimum

import quota of 1.256 million MT of sugar in 1990. In the meantime, HFCS had been gaining its share in the U.S. sweetener market since the early 1970s when commercial production of HFCS became possible by the advancement of wet-milling technology. Today, more than 50 percent of caloric sweetener consumption in the United States is derived from corn syrup including HFCS (Congressional Research Service, Library of Congress, 1999). A similar phenomenon appears to be beginning in Mexico. The implementation of NAFTA resulted in open the door for HFCS consumption in Mexico where nearly all of the caloric sweetener consumption was derived from domestically-produced sugar before 1994. Reflecting this threatening trend of replacing domestic sugar consumption with HFCS, in 1996 the Mexican government imposed tariffs on HFCS claiming that the U.S. companies were dumping HFCS at an unfair price and affecting the export volume and value of Mexican sugar. This action evolved into a trade dispute between the United States and Mexico and ended when the WTO panel ruled against Mexico's claim (Garcia et al., 2002 and 2004). Overall, NAFTA has not brought about significant changes in the U.S. sugar market because the Mexican exporters have been unable to significantly expand shipments to the United States. Rather, attention was poured into issues with HFCS which posed an immediate impact on Mexican sweetener market.

Looking ahead in the sweetener markets in both the United States and Mexico, several questions remain unanswered. How much sugar surplus Mexico will generate; how much sugar will cross the border both under- and over-quota; what will happen after 2008 when all the restrictions are eliminated on Mexican sugar; what is the impact of Mexico's HFCS adoption in both sweetener markets; and what are the political

implications on U.S. sugar program as a consequence of the above? In this study, the direction of the U.S.-Mexico sugar trade was examined through quantitative methods, paying close attention to HFCS. A bilateral trade model between the U.S. and Mexico using mathematical programming provides insights for the market balance in the future including political implications.

Empirical Models

The empirical procedures consist of two components: demand and supply analysis models for both the U.S. and Mexican sugar markets; and a bilateral sugar trade analysis model, which was built upon the results from the former.

First, demand and supply elasticities for sugar were estimated by regression using time-series data. Both demand and supply equations were specified in double-log form with a price variable and other associated shifters used as explanatory variables. Serial correlation was anticipated and corrected by the Yule-Walker Method with appropriate lags assigned. Neither demand nor supply for HFCS was estimated in either country due to limited availability of HFCS price data.

Second, a U.S.–Mexico bilateral sugar trade model was built based on a spatial equilibrium model developed by Takayama and Judge (1964). This model provides the optimal equilibrium price and quantity through maximization of welfare in each country, i.e. the sum of the consumer and producer surplus, given the demand and supply equations and the transportation cost between two regions. Linear inverse demand and supply equations (price endogenous) were formulated using estimated elasticities from the previous analysis and built in the objective function (Spreen et al., 2000). Transfer costs such as transportation cost and tariffs are considered as loss in welfare and were

also incorporated in the objective function. Necessary conditions, i.e. demand-incoming shipment and supply-outgoing shipment balance as well as ones specific to the bilateral trade model such as Mexico's quota allocation under NAFTA and U.S. price support were assigned as constraints. The model was solved by using the mathematical programming software package GAMS.

In order to run simulations on the bilateral model, several assumptions were made. The quantities in the model are raw sugar equivalent. In doing so, the price difference along the vertical market channel was ignored. Changes in sugar stocks in both countries were also ignored and hence the excess sugar supply from Mexico and the excess sugar demand from the United States were captured as the differences between sugar demand and supply in each country. Although HFCS demand and supply were not directly estimated, a shift in sugar demand at industry level caused by a change in HFCS demand in Mexico was simulated through HFCS adoption forecast. The model was calibrated with the actual values realized in 2001 (base year) and iterated for solutions from 2002 through 2015. Slopes for both inverse demand and inverse supply curves were held constant, yet these curves were designed to shift over the forecast horizon according to the scenarios proposed in the study.

Verification of the bilateral sugar trade model

The model is verified by checking the first-order conditions obtained through using Kuhn-Tucker theorem. The objective function of the U.S.–Mexico bilateral sugar trade model and associated constraints are defined as:

$$Max \quad \int (U_1 + U_2 * Q^D_{US,t} + Shifter^D_{US,t})\, dQ^D_{US,t}$$

$$+ \int (M_1 + M_2 * Q^D_{MX,t} + Shifter^D_{MX,t})\, dQ^D_{MX,t}$$

$$- \int (UU_1 + UU_2 * Q^S_{US,t} + Shifter^S_{US,t})\, dQ^S_{US,t}$$

$$- \int (MM_1 + MM_2 * Q^S_{MX,t} + Shifter^S_{MX,t})\, dQ^S_{MX,t}$$

$$- (T_{MX,US}) * X_{MX,US,t}$$

$$- (T_{US,MX}) * X_{US,MX,t}$$

$$- (T_{MX,US} + OQTar_{MX,US,t}) * XX_{MX,US,t}$$

$$- (T_{ROW,US} + P_{ROW}) * X_{ROW,US,t}$$

$$+ P_{ROW} * X_{MX,ROW,t} \qquad (1)$$

s.t.

$$Q^D_{US,t} - X_{US,US,t} - X_{MX,US,t} - XX_{MX,US,t} - X_{ROW,US,t} \leq 0 \qquad (2)$$

$$Q^D_{MX,t} - X_{MX,MX,t} - X_{US,MX,t} \leq 0 \qquad (3)$$

$$- Q^S_{US,t} + X_{US,US,t} + X_{US,MX,t} \leq 0 \qquad (4)$$

$$- Q^S_{MX,t} + X_{MX,MX,t} + X_{MX,US,t} + XX_{MX,US,t} + X_{MX,ROW,t} \leq 0 \qquad (5)$$

$$X_{MX,US,t} - Quota_t \leq 0 \qquad (6)$$

$$X_{ROW,US,t} + XX_{MX,US,t} - USMin_t \geq 0 \qquad (7)$$

where *US*, *MX*, *ROW* represent Mexico, the U.S. and the rest of the world, respectively; Q^D and Q^S are quantity demanded and supplied, respectively; $X_{i,j}$ and $XX_{i,j}$ are quantity shipped from *i* to *j* under-quota and over-quota, respectively; *t* is a time period from 2002 to 2015; T_{ij} is a per unit transportation cost from *i* to *j;* $OQTar_{MX,US,,t}$ is a per unit over-quota tariff imposed on Mexican sugar shipped to the United States in year *t* according to the tariff schedule under NAFTA provisions*;* P_{ROW} is a world price of raw sugar; $Quota_t$ is the quota allocated to Mexico in year *t* under NAFTA provisions; and $USMin_t$ is the quota allocated to the rest of the world in year *t* (the U.S. minimum sugar import

requirement less the quota allocated to Mexico). Note that the transportation cost within a country is assumed to be zero. The transfer cost of sugar from the rest of the world to the United States includes the price of sugar; i.e. sugar shipped from the rest of the world and Mexico compete with each other to enter the U.S. market. The last term in the objective function considers Mexico's sales of sugar to the rest of the world. Constraints define the balances between the incoming shipment and the quantities demanded as well as outgoing shipment with the quantities supplied; and quotas imposed on Mexican sugar and from the rest of the world.

Lagrangian form (L) of the maximization problem is given as:

$$
\begin{aligned}
L = \; & (1/2)^* U_2^*(Q^D_{US,t})^2 + (U_1 + Shifter^D_{US,t})^*Q^D_{US,t} \\
& + (1/2)^* M_2^*(Q^D_{MX,t})^2 + (M_1 + Shifter^D_{MX,t})^*Q^D_{MX,t} \\
& - (1/2)^* UU_2^*(Q^S_{US,t})^2 + (UU_1 + Shifter^S_{US,t})^*Q^S_{US,t} \\
& - (1/2)^* MM_2^*(Q^S_{MX,t})^2 + (MM_1 + Shifter^S_{MX,t})^*Q^S_{MX,t} \\
& - (T_{MX,US})^*X_{MX,US,t} \\
& - (T_{US,MX})^*X_{US,MX,t} \\
& - (T_{MX,US} + OQTar_{MX,US,t})^*XX_{MX,US,t} \\
& - (T_{ROW,US} + P_{ROW})^*X_{ROW,US,t} \\
& + P_{ROW}^*X_{MX,ROW,t} \\
& + V_{US,t}(X_{US,US,t} + X_{MX,US,t} + XX_{MX,US,t} + X_{ROW,US,t} - Q^D_{US,t}) \\
& + V_{MX,t}(X_{MX,MX,t} + X_{US,MX,t} - Q^D_{MX,t}) \\
& + W_{US,t}(Q^S_{US,t} - X_{US,US,t} - X_{US,MX,t}) \\
& + W_{MX,t}(Q^S_{MX,t} - X_{MX,MX,t} - X_{MX,US,t} - XX_{MX,US,t} - X_{MX,ROW,t}) \\
& + \lambda_t(Quota_t - X_{MX,US,t})
\end{aligned}
$$

$$+ \ \sigma_t (X_{ROW,\,US,\,t} + XX_{MX,\,US,\,t} - USMin_t) \tag{8}$$

where V, W, λ and σ are Kuhn-Tucker multiplier associated with each constraint representing the imputed marginal value of price of sugar demanded, supplied, that of Mexican sugar exported under-quota and that of over-quota, respectively. Note that λ is positive in sign and σ is negative, reflecting the way these associated constraints are defined. By omitting the time notation t, Kuhn-Tucker conditions for a typical time period are expressed as follows:

$$\frac{\partial L}{\partial Q^D_{US}} = U_2 * Q^D_{US} + U_1 + Shifter^D_{US} - V_{US} \le 0, \frac{\partial L}{\partial Q^D_{US}} * Q^D_{US} = 0, \ Q^D_{US} \ge 0 \tag{9}$$

$$\frac{\partial L}{\partial Q^S_{US}} = -(UU_2 * Q^S_{US} + UU_1 + Shifter^S_{US}) + W_{US} \le 0, \frac{\partial L}{\partial Q^S_{US}} * Q^S_{US} = 0, Q^S_{US} \ge 0 \tag{10}$$

$$\frac{\partial L}{\partial Q^D_{MX}} = M_2 * Q^D_{MX} + M_1 + Shifter^D_{MX} - V_{MX} \le 0, \frac{\partial L}{\partial Q^D_{MX}} * Q^{TC}_{MX} = 0, Q^D_{MX} \ge 0 \tag{11}$$

$$\frac{\partial L}{\partial Q^S_{MX}} = -(MM_2 * Q^S_{MX} + MM_1 + Shifter^S_{MX}) + W_{MX} \le 0, \frac{\partial L}{\partial Q^S_{MX}} * Q^S_{MX} = 0, Q^S_{MX} \ge 0 \tag{12}$$

$$\frac{\partial L}{\partial X_{US,US}} = V_{US} - W_{US} \le 0, \ \frac{\partial L}{\partial X_{US,US}} * X_{US,\,US} = 0, \ X_{US,\,US} \ge 0 \tag{13}$$

$$\frac{\partial L}{\partial X_{MX,MX}} = V_{MX} - W_{MX} \le 0, \frac{\partial L}{\partial X_{MX,MX}} * X_{MX,\,MX} = 0, \ X_{MX,\,MX} \ge 0 \tag{14}$$

$$\frac{\partial L}{\partial X_{MX,US}} = -T_{MX,\,US} + V_{US} - W_{MX} - \lambda \le 0, \ \frac{\partial L}{\partial X_{MX,US}} * X_{MX,\,US} = 0, \ X_{MX,\,US} \ge 0 \tag{15}$$

$$\frac{\partial L}{\partial X_{US,MX}} = -T_{US,\,MX} + V_{US} - W_{MX} \le 0, \frac{\partial L}{\partial X_{US,MX}} * X_{US,\,MX} = 0, \ X_{US,MX} \ge 0 \tag{16}$$

$$\frac{\partial L}{\partial XX_{MX,US}} = -T_{MX,\,US} - OQTar_{MX,\,US} + V_{US} - W_{MX} + \sigma \le 0, \frac{\partial L}{\partial X_{MX,US}} * X_{MX,\,US} = 0,$$

$$X_{MX,\,US} \geq 0 \tag{17}$$

$$\frac{\partial L}{\partial X_{ROW,US}} = -T_{ROW,\,US} - P_{ROW} + V_{US} + \sigma \leq 0, \quad \frac{\partial L}{\partial X_{ROW,US}} * X_{ROW,\,US} = 0,$$

$$X_{ROW,\,US} \geq 0 \tag{18}$$

$$\frac{\partial L}{\partial X_{MX,ROW}} = P_{ROW} - W_{MX} \leq 0, \quad \frac{\partial L}{\partial X_{MX,ROW}} * X_{MX,\,ROW} = 0, \; X_{MX,\,ROW} \geq 0 \tag{19}$$

By solving equations above, the following conditions must hold at the equilibrium [a)]:

$$V_{US} = P^{D}_{US} = W_{US} = P^{S}_{US} \tag{20}$$

$$V_{MX} = P^{D}_{MX} = W_{MX} = P^{S}_{MX} \tag{21}$$

$$P^{D}_{US} \leq P^{S}_{MX} + T_{MX,\,US} + \lambda \tag{22}$$

$$P^{D}_{MX} \leq P^{S}_{US} + T_{US,\,MX} \tag{23}$$

$$P^{D}_{US} \leq P^{S}_{MX} + T_{MX,\,US} + OQTar_{MX,\,US} - \sigma \tag{24}$$

$$P^{D}_{US} \leq P_{ROW} + T_{ROW,\,US} - \sigma \tag{25}$$

$$P_{ROW} \leq P^{D}_{MX} \tag{26}$$

Complementary slackness conditions indicate that if Mexico exports sugar to the U.S. under-quota ($X_{MX,\,US} > 0$), then the demand price in the United States should not exceed the value of exporting Mexican sugar, which is equivalent to the sum of the supply price, transportation cost and the marginal value of exporting sugar under-quota (equation [22]). By the same token, if Mexico exports sugar to the U.S. over-quota ($XX_{MX,\,US} > 0$), then the demand price in the United States should not exceed the sum of the Mexican supply price, transportation cost, tariff imposed on over-quota sugar and the marginal value of exporting sugar under-quota (equation [24]). The inequality of the prices expressed in equation [26] accords with reality. If both over-quota export from

Mexico ($XX_{MX, US}$) and export from the rest of the world ($X_{MX, US}$) are greater than zero, the following must also hold from equations [24] and [25].

$$P^S_{MX} - P_{ROW} = T_{ROW, US} - T_{MX, US} - OQTar_{MX, US} \quad (27)$$

This equation implies that when the price difference between Mexico and the rest of the world is equal to the difference in transfer cost (transportation cost and tariff), both the over-quota export from Mexico and the export from the rest of the world occur at the same time. In other words, Mexico would export over-quota only if the transportation cost from the rest of the world is high enough to justify Mexico to do so. Based on this relationship, the model was further calibrated by adjusting the average transportation cost from the rest of the world to the United States to adequately reflect the Mexican sugar supply and export capacity: the transportation cost is calibrated so that Mexico exports sugar over-quota at the minimum amount. This calibration procedure resulted in a rather high transportation cost from the rest of the world to the United States; however, it insinuates the irrational behavior of the Mexican sugar industry which has been suffering from financial stress, vividly illustrated by the mill expropriation by the government in 2001, and producing and exporting surplus sugar to the rest of the world at the same time.

Scenarios to simulate

Scenarios were formulated by considering alternative assumptions related to HFCS consumption, continued gains in the productivity of the Mexican sugar industry and the U.S. policy levers. In this paper, five scenarios are proposed and summarized in Table 1. Scenario 1 represents the situation where status quo is maintained; Scenario 2 considers faster improvement in Mexican production; and Scenario 3 assumes Mexico will adopt HFCS at high rate in addition to production improvement. These three scenarios assume

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[a)] Assuming non-zero production and consumption in both the Unites States and Mexico.

that the U.S. government allocates sugar quota in a flexible manner between Mexico and the rest of the world. By contrast, Scenario 4 considers the situation where the U.S. government maintains minimum quotas (the remaining of the minimum import requirement less allocated to Mexico) to the rest of the world no matter how much Mexico exports to the United states. Scenario 5 considers the situation where the U.S. government buys up the excess sugar in the market instead of maintaining the existing price support. Scenario 4 and 5 are the scenarios that consider the different quota allocation or alternative Sugar program, respectively.

Pay-offs from each scenario were calculated for three industries (the U.S. HFCS industry, the U. S. sugar industry and the Mexican sugar industry) and two countries (the U.S. and Mexico). Pay-offs to the industries were expressed as present values of accumulated revenue between 2002 and 2015, assuming a three percent discount rate each year. HFCS price was held constant at the average U.S. export price to Mexico realized between 1992 and 2001. Pay-offs to the countries were expressed as present values of accumulated welfare, i.e. the sum of consumer and producer surplus. The U.S. welfare was adjusted with the tariff revenue from Mexico, the cost of the sugar program and the cost of buying up excess sugar. The cost of the sugar program was calculated using the loan rate for raw sugar (18 cents per pound). The cost of buying up the excess sugar was calculated using the U.S. net sugar import, i.e. total sugar import less 1,256,000 MT of minimum import requirement. Note that since the values were converted in terms of U.S. dollars prior to simulations, the exchange rate realized in the base year (2001) was implicitly used for calculating pay-offs.

Data

Data for the Mexican sugar industry was obtained from the website of Comité de la Agroindustria Azucarera (COAAZUCAR, Sugar Agro-Industry Committee). The committee is in charge of monitoring sugar cane and sugar production at each mill as well as determining cane price paid to farmers in the country. The latter task was taken over from the former government body after the privatization of the industry. The committee carries extensive data set regarding not only physical production and price but also detailed productivity and efficiency indicators such as sugar and fiber contents in cane, mill down- time and sugar production loss during the process across operating 60 mills. Data for the U.S. sugar industry was obtained from the Sugar and Sweetener Situation and Outlook Yearbook and some other publications by the Economic Research Service, USDA. Historic data for population were obtained form the website of the U.S. Bureau of the Census; and those for GDP, exchange rates and consumer price index were taken from OECD documents.

Results

Demand and supply analysis

The results for the U.S. demand and supply analysis are summarized in Table 2. In the demand analysis, signs of estimates associated with each significant variable was as expected. Significant estimates at 95 percent confidence level were associated with price, the dummy variables for quarter 1 and 3, and the dummy variable for HFCS availability. The estimated price elasticity of demand was inelastic. The significant estimate associated with HFCS dummy variable implies that HFCS replaces sugar as a substitute in the market. In the supply analysis, estimates associated with trend and production in the previous year (autoregressive term) were significant at 95 percent confidence level for

all three (total, beet and cane sugar) supply regression models. Estimates associated with sugar recovery rate were insignificant in all models. Estimates associated with price and cost were significant at 95 confidence level for total and beet sugar supply regressions, but not for the cane sugar supply equation. Two possible reasons why cane sugar production does not respond to the refined sugar price but beet sugar production does are: (1) cane sugar requires two steps in the refinery process while beet sugar has one and (2) sugarcane is perennial crop while beet is an annual. The results imply that sugar beet production is more sensitive to price changes. Although cane sugar production is assumed to respond to raw sugar price, the coefficient of the price variable is not significant. Estimated price elasticities were both inelastic for total sugar and beet sugar as anticipated.

The results for the Mexico demand and supply analysis are summarized in Table 3. In the demand analysis, signs of significant estimates associated with each variable were consistent with a priori expectations. The only statistically significant estimate among the three price elasticities was direct consumption, and it was inelastic. Population variables accounted for most of the explanatory power of consumption in all models. The significant estimate associated with GDP in indirect sugar and total sweetener consumption indicates that consumers tend to consume more sugar through sugar-contained products as their incomes increase. In the supply analysis, the signs of estimates associated with each variable corresponded with a priori expectations. The estimate associated with price was inelastic. While reduction in production cost and factory down-time indicate an increase in production, the length of sugarcane harvest duration was almost parallel to sugar production. The insignificant estimate associated

with sugar loss during the process implies that the degree of sugar loss is not as critical as other factors such as production cost and factory down-time for the mills to improve their production efficiency. The positive and significant estimate associated with trend indicates technology related to sugar production at sugar mills had been advancing during the years covered by the observed period.

U.S. -Mexico bilateral sugar trade analysis

U.S. sugar import forecasts for the selected four scenarios are illustrated in Figure 1 through 4. The results from baseline scenario (Scenario 1) shows that if status quo surrounding sugar industries in both countries is maintained over the forecast horizon, Mexico will not likely attain a net surplus sweetener producer status and hence will miss the opportunity to benefit from exporting sugar to a larger quota allocation (250,000 MT) under NAFTA (Figure 1). This is due to growing domestic sugar demand relative to sugar production. When Mexico expands sugar production (Scenario 2), there will be still no chance for Mexico to attain a net surplus sweetener producer status (Figure 2). Yet, Mexico will generate enough surplus sugar to export over-quota (before 2008) and quota-free (after 2008), resulting in significant impacts on the U.S. market: Mexican sugar will take up about one-third (Scenario 1) or more than half (Scenario 2) of the U.S. minimum import requirement at peak. The amount of export will decline in later years due to expanding domestic sugar consumption in Mexico.

In Scenario 3, Mexico adopts HFCS at a high rate. The results include direct impacts on the Mexican sweetener market as well as extended impacts on the U.S. sweetener market (Figure 3). Although Mexico will not attain a net surplus sweetener producer status, over-quota export will reach over 1,200,000 MT and after 2007 quota-free export continue to remain over 1,000,000 MT for the rest of the forecast horizon.

This export quantity will take up almost the entire U.S. minimum import requirement and as a result, sugar export from the rest of the world will be marginalized.

The U.S. government's quota allocation poses large impacts on both Mexican sugar and sugar from the rest of the world. The aforementioned large-scale export of Mexican sugar is possible only if the U.S. imports the minimum amount of sugar and allocates sugar quotas in a flexible manner among exporters. This allocation method may cause friction with the other sugar exporters since Mexican sugar has potential to take up a large portion of the U.S. quota and thus it may not become feasible policy option. In Scenario 4, it is conjectured that the U.S. government maintains the minimum quotas (the remaining of the minimum import requirement less allocated to Mexico) for the rest of the world no matter how much Mexico exports. As shown in Figure 4, Mexico's over-quota and quota-free export will be dampened because of Mexico's comparative disadvantage to the rest of the world, while the export from the rest of the world remain over 1,200,000 MT over the entire forecast horizon.

In spite of the fluctuating import from Mexico and the rest of the world, U.S. domestic sugar consumption and production will remain relatively unchanged. The results from the simulations showed that the U.S. sugar price will gradually decline but will not dip below support price level before 2008 if the United States accepts most of the import sugar from Mexico rather than from the rest of the world. This implies that the Mexican sugar price contributes to maintain a high sugar price in the integrated the U.S.-Mexico sugar market; in other words, accommodating Mexican sugar can act as an alternative form of price support in the United states. In reality, the U.S. sugar price will

face downward pressure from importing world sugar as well as political pressure from the rest of the world.

Pay-offs to the industries and countries also portrayed interesting contrasts among scenarios. The results from the selected three scenarios (Scenario 1, Scenario 4 and Scenario 5) are summarized in Table 4. It is clear that the U.S. HFCS industry will become better off if Mexico adopts HFCS: revenue for the U.S. HFCS industry increases by 78 percent. Among five entities (three industries and two countries), the U.S. sugar industry will be affected the least in a relative sense by the changes in situation or the U.S. sugar policy.

An extreme result comes from Scenario 4. In this scenario, the U.S. sugar program will become extremely costly if the U.S. government reserves the minimum quota for the rest of the world. As a result of cheap sugar from the rest of the world flowing into the U.S. market, the U.S. demand price will fall far below the support price. The sugar industries and welfare in both countries will decline significantly compared to the baseline, particularly Mexican sugar industry: it would lose nearly a half of its expected revenue.

An alternative U.S. sugar policy may bring about some improvement in the U.S. welfare (Scenario 5). In addition to the benefit from Mexico's HFCS adoption, switching the price support into buying up the excess sugar turns out beneficial; increased tariff revenue from Mexican sugar exceeds the cost of buying up excess sugar. Yet, this scenario does not satisfy pareto optimality.

If the U.S. government were to switch policies from the price support to buying up excess sugar, the timing to do so will be important so as to minimize the cost incurred

by the government. The cost of buying up excess sugar will rise immediately after policies are switched while the cost of the price support will not because the U.S. sugar price will be maintained relatively high in the early stage of the forecast horizon. This will be particularly true if the U.S. accepts a large quantity of sugar from Mexico.

Conclusions

NAFTA brought about the mixed impacts on the United States and Mexico, and some were different from what was expected. The Mexican sugar industry benefited little in the past ten years of NAFTA regime and may not expect much in the future either. The opportunity for Mexico to export sugar to 250,000 MT of the expanded quota, which is roughly 20 percent of the U.S. minimum import requirement, seems unlikely to be enjoyed due to Mexico's tight production compared to its sweetener consumption. Yet, Mexico possesses a large potential to export over-quota as well as quota-free which will happen when all the restrictions are lifted. The magnitude of over-quota and quota-free export depends on the magnitude of Mexico's sugar production expansion and HFCS adoption. Particularly if Mexico adopts HFCS at an increasing rate, a considerable amount of surplus sugar will be generated, which poses a direct impact on the Mexican sugar industry and an extended impact on the U.S. market as well. As seen in the trade dispute over HFCS, Mexico will continue to struggle to suppress HFCS adoption in its market.

By comparison, NAFTA did not bring about drastic change to the U.S. market: expanded exports from Mexico have failed to materialize. Although various simulations showed fluctuating sugar export to the United States from Mexico and the rest of the world in the future, U.S. domestic sugar production and consumption will remain relatively unchanged. What affects the sugar exporters greatly will be the way the U.S.

government allocates quotas among exporters. Although the Mexican sugar price contributes to maintain a high sugar price in the U.S. market as if acting as an alternative form of price support, allocating a large portion of quota to Mexico may not be politically feasible. The U.S. government may seek an alternative policy besides the price support since the price support may become very costly when combined with the situation where the U.S. government promises to accept a large amount of sugar from the rest of the world. One scenario showed that the U.S. government may be able to abandon the price support and buying up the excess sugar in the market instead, resulting in an improvement in welfare brought by increased tariff revenue and a reduced cost. This particular scenario may appear plausible; however, the conflicts of interest among industries are left unconsidered. Close examinations will be necessary to find a proper policy change by taking a decision making process into consideration.

Table 1. Details of the Scenarios

Scenarios	Factors	Country	Assumptions
Baseline (Scenario 1)	GDP	U.S. and Mexico	Will increase at the average real GDP annual growth rate realized between 1997 and 2001 (1.0223 for the U.S. and 1.0291 for Mexico)
	Population	U.S. and Mexico	Will increase similarly as the forecast by the U.S. Bureau of the Census. (Annual growth rate: 1.0088 for the U.S. and 1.0115 for Mexico)
	Production cost	U.S. and Mexico	Will decrease at the average annual reduction rate realized between 1997 and 2001. (0.989 for the U.S. and 0.982 for Mexico)
	Recovery rate	U.S.	Will increase at the average annual improvement rate realized between 1997 and 2001. (1.0048)
	Down-time	Mexico	Will decrease at the average annual reduction rate realized between 1997 and 2001. (0.990)
	Sugar loss	Mexico	Will decrease at the average annual reduction rate realized between 1997 and 2001. (0.980)
	Duration of harvest	Mexico	Held constant (1)
	HFCS consumption	Mexico	Will be consumed at the same ratio to the indirect consumption of sugar realized in 2001. (0.253)
High Mexican Production (Scenario 2)	Production cost, Down-time, Sugar loss	Mexico	Will improve additional 1 percent to the "Baseline".
	Other shifters	U.S. Mexico	The same as "Baseline"
High Mexican Poduction – HFCS adoption (Scenario 3)	Production cost, Down-time, Sugar loss	Mexico	The same as "High Mexican Production"
	HFCS consumption	Mexico	It is assumed that HFCS consumption will increase in a linear fashion until it replaces 50 percentage of the indirect consumption of sugar in 2008. After 2008, the substitution rate remains at 50 percent.
	Other shifters	U.S. Mexico	The same as Baseline
High Mexican Poduction – HFCS adoption (Scenario 4)	Shifters	U.S. Mexico	The same as "High production – HFCS adoption"
	Quota allocations to the rest of the world	The rest of the world	The U.S. government reserves the minimum quotas (the remaining minimum import requirement less allocated to Mexico) for the rest of the world.
High Mexican Poduction – HFCS adoption (Scenario 5)	Shifters	U.S. Mexico	The same as "High production – HFCS adoption"
	U.S. price support	U.S.	U.S. government abandons the price support and buys up the excess sugar in the market instead.

Unless mentioned, U.S. price support and flexible quota allocations to the rest of the world are assumed.

Table 2. Summary of the U.S. Demand and Supply Analysis

Country	U.S.			
Dependent variables / Independent variables	Demand	Supply		
	Consumption of sugar	Production of sugar	Production of beet sugar	Production of cane sugar
Number of observations	132	43	43	43
Degree of freedom	124	36	36	36
Real retail price of refined sugar [1)]	-0.2323 (-4.23) **			
Real per capita GDP [1)]	0.1378 (0.29)			
Population	-0.6470 (-0.71)			
Dummy variable (Quarter=1)	-0.0707 (-5.26) **			
Dummy variable (Quarter=2)	0.0136 (1.18)			
Dummy variable (Quarter=3)	0.0941 (10.14) **			
Dummy variable for availability of HFCS	-0.1853 (-3.89) **			
Trend		0.0067 (2.94) **	0.0069 (3.20) **	0.0091 (3.08) **
Real retail price of refined sugar in the previous year [1)]		0.1471 (2.35) **	0.2195 (2.19) **	0.0711 (1.44)
Real total farm production expenses [1)]		-0.2316 (-2.19) **	-0.3986 (-2.74) **	-0.0830 (-1.34)
Sugar recovery rate		-0.2351 (-0.57)	-0.5829 (-1.55)	0.1863 (0.58)
Production in the previous year		0.6204 (5.26) **	0.6755 (5.37) **	0.3672 (3.24) **
Constant	19.8376 (1.52)	5.9033 (2.65) **	7.8421 (3.22) **	5.0365 (6.12) **
Total R^2	0.8645	0.8950	0.7253	0.9489
Durbin-Watson [2)]	2.0563 (1) 2.5487 (2)	2.0495 (1) 2.0325 (2)	2.0968 (1) 2.0525 (2)	2.0399 (1) 1.9725 (2)

* and **: Significant at 90% and 95% confident level, respectively.

1) Deflated by CPI.

2) Values are after corrected by Yule-Walker method. ( ) corresponds to the order of lag assigned.

Table 3. Summary of the Mexican Demand and Supply Analysis

Country	Mexico			
Dependent variables / Independent variables	Demand			Supply
	Direct consumption of sugar	Indirect consumption of sugar	Total consumption of sweeteners	Production of sugar
Number of observations	30	30	30	13
Degree of freedom	26	25	25	6
Real retail price of standard sugar 1)	-0.0734 (-1.93) *	-0.003535 (-0.07)	-0.0215 (-0.98)	
Real per capita GDP 1)	-0.2595 (-1.37)	0.9213 (2.96) **	0.4363 (3.33) **	
Population	1.1194 (8.51) **	1.4175 (5.39) **	1.2486 (10.92) **	
Dummy variable for availability of HFCS		-0.1025 (-1.58)	-0.0250 (-0.88)	
Real wholesale price of standard sugar in the previous year 1)				0.2152 (2.52) *
Real production cost per ton of sugar 1)				-0.3228 (-7.89) **
Down-time				-0.4275 (-6.77) **
Loss of sugar during the process				-0.2112 (-1.64)
Duration of the harvest				1.0010 (9.13) **
Trend				0.5435 (12.75) **
Constant	-3.4499 (-2.72) **	-20.5135 (-6.90) **	-11.9624 (-8.91) **	11.8453 (20.89) **
Total R^2	0.9344	0.9729	0.9905	0.7380
Durbin-Watson 2)	1.9217 (1) 1.9961 (2)	1.5933 (1) 1.5357 (2) 1.1648 (3)	1.8715 (1) 1.5834 (2)	2.9128 3)

* and **: Significant at 90% and 95% confident level, respectively.

1) Deflated by CPI.

2) Values are after corrected by Yule-Walker method. ( ) corresponds to the order of lag assigned.

3) Indicates neither positive nor negative correlation.

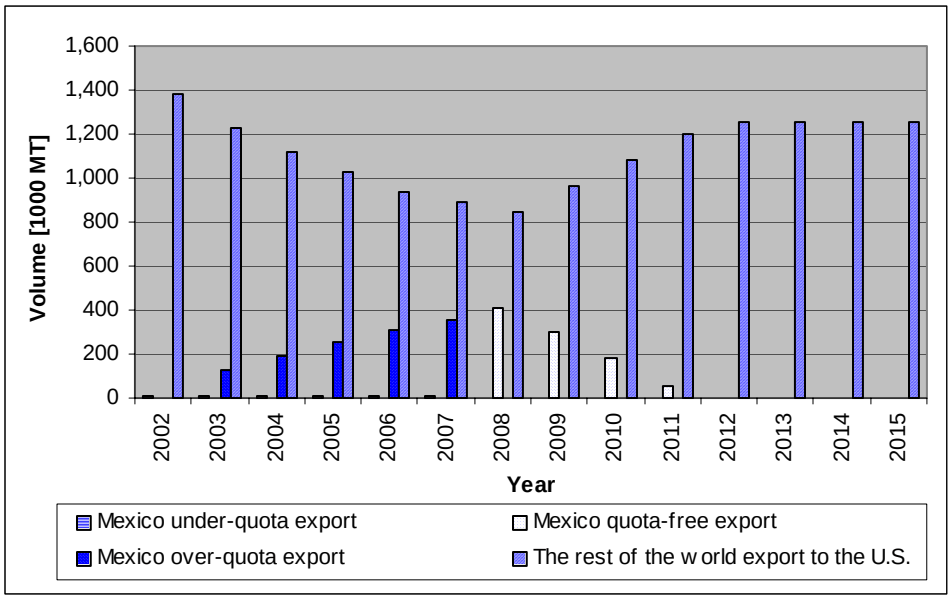

Figure 1. The U.S. Sugar import Forecast (Scenario 1)

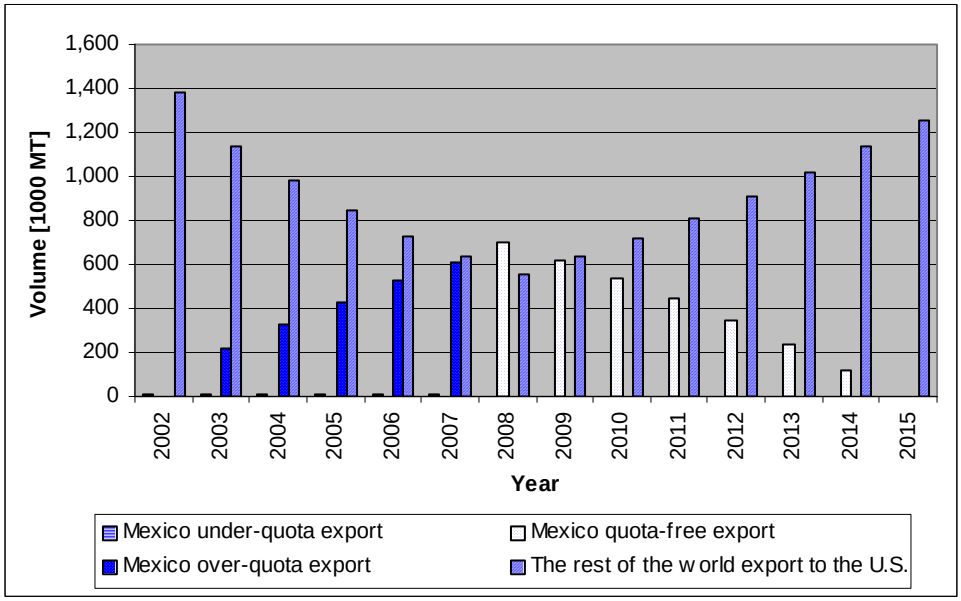

Figure 2. The U.S. Sugar import Forecast (Scenario 2)

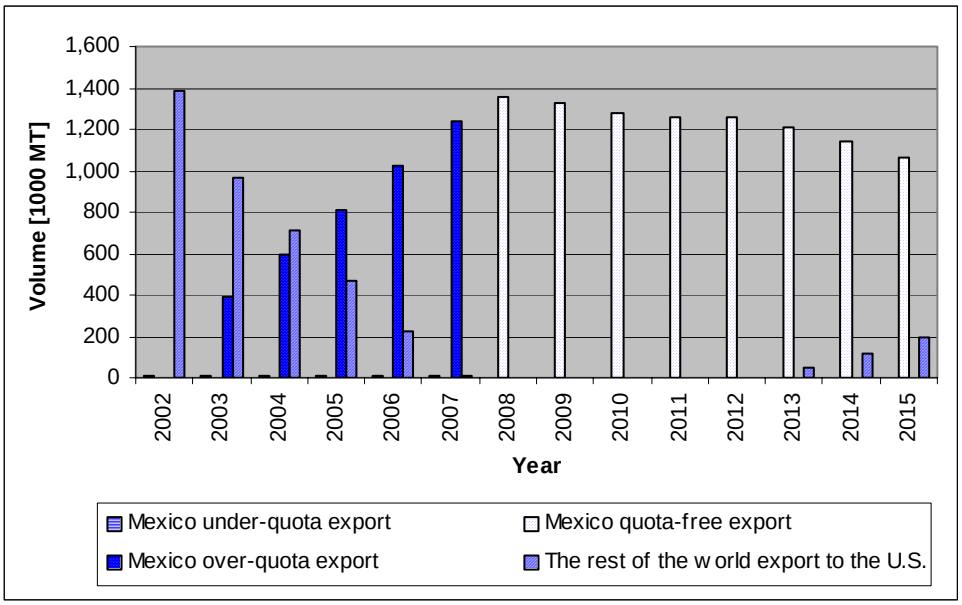

Figure 3. The U.S. Sugar import Forecast (Scenario 3)

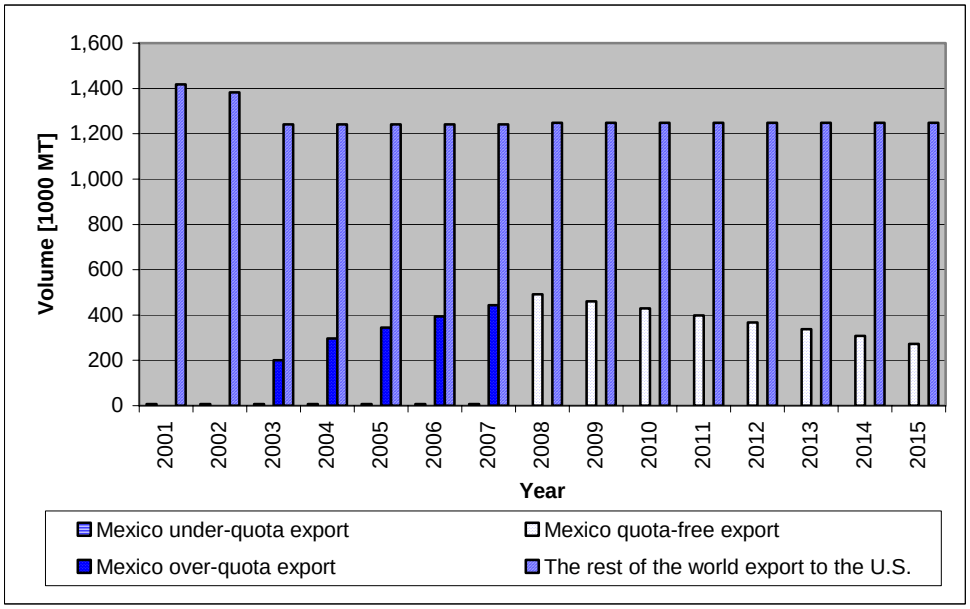

Figure 4. The U.S. Sugar import Forecast (Scenario 4)

Table 4. Present Value of the Accumulated Pay-offs [billion US$]

Scenarios		Scenario 1	Scenario 4	Scenario 5
U.S.	HFCS industry revenue	5.684 (100)	10.132 (178.3)	10.132 (178.3)
	Sugar industry revenue	35.713 (100)	33.480 (93.7)	35.206 (98.6)
	Welfare (a)	354.486 (100)	344.115 (97.1)	354.744 (100.1)
	Tariff revenue from Mexican sugar (b)	0.093 (100)	0.133 (142.9)	0.297 (320.1)
	Cost of price support program (c)	0.208 (100)	6.112 (2,931.5)	0 (n/a)
	Cost of buying up excess sugar (d)	0 (100)	0 (n/a)	0.191 (n/a)
	Net cost (c+d-b)	0.116 (100)	5.979 (5,168.8)	-0.106 (-91.6)
	Adjusted welfare (a+b-c-d)	354.370 (100)	338.136 (95.4)	354.850 (100.1)
Mexico	Sugar industry revenue	21.737 (100)	12.159 (55.9)	21.315 (98.1)
	Welfare	74.443 (100)	69.095 (92.8)	72.293 (97.1)

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