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Master's Thesis in Economics

Analyzing Price Stabilization Effects of Government Sugar Programs: Pre- and Post-NAFTA

정부 설탕 정책의 가격 안정성 효과 분석: NAFTA를 통한 시장개방 전후를 중심으로

August 2017

Department of Agricultural Economics and Rural Development

Seoul National University

CHERRY KIM

Analyzing Price Stabilization Effects of Government Sugar Programs: Pre- and Post-NAFTA

Adviser: Professor Kwansoo Kim

Thesis submitted in partial fulfillment of the requirements for the degree of Master of Arts in Economics

July 2017

Department of Agricultural Economics and Rural Development
Seoul National University

CHERRY KIM

Confirming the master's thesis written by Cherry Kim

July 2017

Supervisory Committee:

Chair _____

Vice Chair _____

Examiner _____

Abstract

Analyzing Price Stabilization Effects of Government Sugar Programs: Pre- and Post-NAFTA

This paper measures the price stabilization effects of the U.S. sugar programs in the midst of complete sugar market liberalization with Mexico under the NAFTA. Previous research reveals that market liberalization in terms of opening a domestic market can either stabilize or increase the volatility of the domestic prices depending on the characteristics of market liberalization. In this regard, we measure the effectiveness of three sugar program pillars (marketing allotments, price support, and tariff rate quota) on mean price and volatility separately. Given the possibility of time-varying volatility reflected by the heteroscedasticity of the error terms, we utilize the Generalized Least Squares model to the U.S. raw cane sugar market, based on monthly data for the period of FY1991-FY2016. The estimation results indicate that the price volatility was exceptionally widened during the NAFTA as it is further evidenced by relatively high value of coefficient of variation. We found that price support through loan program performed as a price shifter while the elimination of import quotas on Mexican sugar weakened the price stabilization effects of the program.

Keywords : Price Stabilization Effect, U.S. Sugar Program, NAFTA

Student Number : 2014-22833

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1. Introduction

The price of sugar in the United States has been a historically important subject to U.S. sugar producers and refiners given the complexities of the U.S. sugar programs and the dynamic features of the world market. A system of protectionist policies for sugar in the United States called the sugar program has successfully administered the price of domestic sugar since 1930s with a main goal to lower sugar production and to raise the market price above U.S. government minimum support price and world sugar prices. Today, sugar is one of the most heavily protected and subsidized commodities in the country. While most sugar-producing countries use trade barriers to protect their own sugar industries, U.S. currently operates price support through loan program and tariff-quota to support domestic refiners and to maintain domestic prices above a certain level. Such price support mechanisms enable the internal sugar prices to stay above cheap foreign sugars (Sweetener Users Association, 2008).

When the North American Free Trade Agreement (NAFTA) became fully implemented for sugar in 2008, a major concern was whether the U.S. government would be able to successfully protect the domestic industry with its current sugar programs when Mexico would be gaining an unlimited access to export duty-free sugar into the U.S. Combined with the commitments to allocate a minimum quantity of sugar import access to foreign suppliers under Uruguay Round Agreement of the General Agreement on Tariffs and Trade (GATT), NAFTA provisions brought the issue of the increase in sugar imports and downward pressure on U.S. sugar prices in consequence (Abler et al, 2008).

In general, market liberalization in terms of opening a domestic market can

stabilize domestic prices since it adds additional markets (i.e., export/import markets), which contributes to a decrease in price volatility. On the other hand, market liberalization in terms of weakening price stabilization policies can increase the volatility of domestic prices. Previous studies on the effects of agricultural commodity market openness on price volatility have raised questions on the level of market barriers and regulatory policies for domestic market protection. Chavas and Kim (2006) documents that market liberalization through lowering the government support price in the late 1990s has increased the volatility of U.S. butter prices. Other studies such as Johnson (1975), and Srinivasan (2001) also analyze that free trade leads to higher internal price volatility. On a contrary, Bale and Lutz (1979) investigates that trade control cause international commodity price instability while stabilizing domestic prices. Meanwhile, Yang, Haigh, and Leatham (2010) discussed that the 1996 FAIR Act caused the prices of major grain commodities such as soybeans and hard winter wheat to fluctuate while the price volatility of oats showed only little change. In contrast, price fluctuation of cotton decreased after the market liberalization policy is implemented. These findings suggest that the impact of agricultural liberalization policies on the volatility of commodity prices may vary across commodities depending on market situations. In the case of U.S. sugar prices, both the opening of markets and the lowering of government intervention have taken place since the implementation of NAFTA. This raises the question of the actual consequences of NAFTA on the volatility of internal sugar prices. Meanwhile, Koo (2002) looked at the impacts of trade liberalization on U.S. sugar industry with the scenario in which the U.S. eliminates its price support and import quotas while other countries maintain their programs. It is expected that

the Caribbean price of sugar is expected to rise because increased imports raise demand for sugar in the world market, and domestic refined sugar price would fall and thereby U.S. sugar producing regions get threatened if only the U.S. eliminates its sugar program. Abler et al (2008) asserts that larger NAFTA imports allows for large public stocks of sugar to accumulate and thereby destabilizes the program's ability to operate at no-cost to taxpayers. With the result obtained from the study, we expect to provide useful insights for the stabilization effect of the sugar program under NAFTA.

The purpose of this study is to measure the price stabilization effects of the U.S. sugar program in the midst of complete sugar market liberalization with Mexico using monthly time-series data for the period from October 1991 to September 2016. The analysis is applied to monthly No. 14/16 U.S. raw cane sugar prices. Our framework for the analysis consists of private cane sugar stock, market supply and demand factors, and policy variables measuring sugar program mechanisms and the effects of NAFTA. In particular, the government support prices (loan rates), lagged private cane sugar stock, and dummy for NAFTA are key variables to be considered. We estimate the effect of the significant variables on mean and variance of prices at which price volatility analysis is done with the coefficients obtained from the mean estimation. We utilize the Generalized Least Squares (GLS) estimation method to allow for a possibility of time-varying volatility reflected by the heteroscedasticity of the error terms.

The organization of this paper is as follows. Section 2 and 3 provides a brief background on the U.S. and international sugar market, and the federal commodity policies associated. Section 4 consists of the data and introduces main methodologies and models used in the analysis. Section 5 respectively discusses

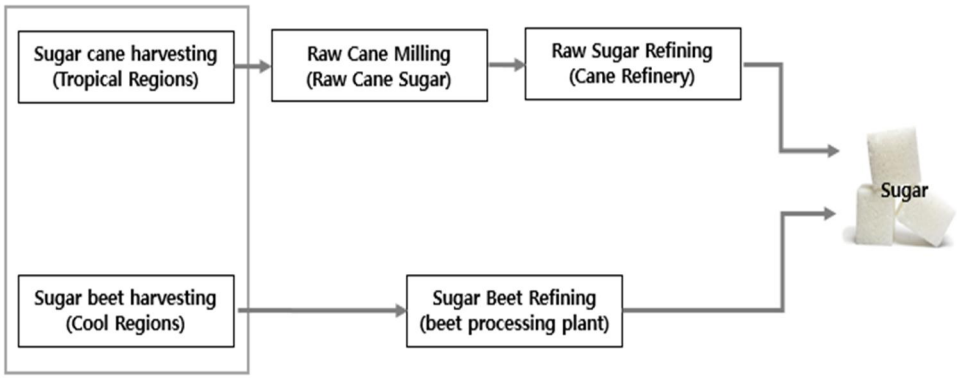
the empirical result of the estimation and the final section of the study concludes.

2. An Overview on the United States Sugar Market and Policy

2.1 The Global Market for Sugar: Production, Consumption, and Trade

The world sugar economy is described by a combination of complicated policies, social and environmental issues affecting both developed and developing countries. Hence, global sugar prices often show highly volatile movements caused by periodic supplying and demand imbalances. Nearly all sugar in world trade today comes from either sugar cane or sugar beets while sugar cane accounts for almost 80 percent in the world market. Cane sugar is grown in hot tropical regions principally in Latin America, Southern Africa and Asia. In contrast, sugar beets are cold tolerant that grows in countries with cool temperatures such as Germany and France. Regardless of its original plant source and refining process, the end-product is sugar. Figure 1 illustrates the different manufacturing processes for the two sugar crops. Both plants must be processed soon after the plants are harvested otherwise their sugar content will drop impulsively.

Figure 1. Sugar Purification from Cane and Beets



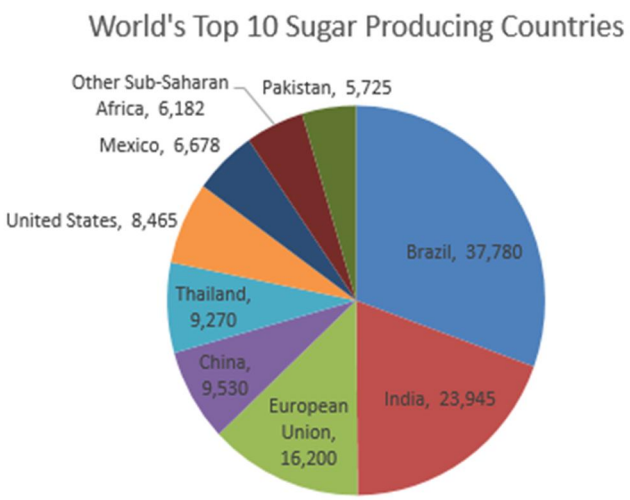
Sugar is produced in more than 100 different countries while Brazil is the leading producer benefited from the favorable weather condition. Brazil respectively accounts for 35% of world sugar cane production and more than 60% of world sugar trade (FAO, 2015). In FY2016/17[1], Brazil produced approximately 37,780 thousand metric tons (TMT) of raw sugar (USDA ERS, 2017). Other major sugar cane producers such as India (23,945TMT), Thailand (9,270TMT), and the United States (8,465TMT) along with Brazil are responsible for more than 70% of world sugar production and exports, which means world sugar supply heavily depends on relatively few major producing countries. In fact, the world sugar price increase in 2005/2006 season was mainly because Brazil increased the bioethanol production from sugarcane making less amount of sugar

[1] Fiscal Year is from September to October

was available for human consumption. Moreover, adverse weather conditions and financial difficulties in Brazil slowed down the production in past several years. Droughts in Thailand and India did affect yields in 2015 as well. In most years, over 70% of world sugar production is consumed domestically and only remaining is traded. In this manner, factors such as ending stocks, general economic situation, and weather conditions in few major producing countries would profoundly impacts the global sugar price movement.

Figure 2. FY2016/17 World's Top 10 sugar producing countries.

Unit: 1,000 MTRV



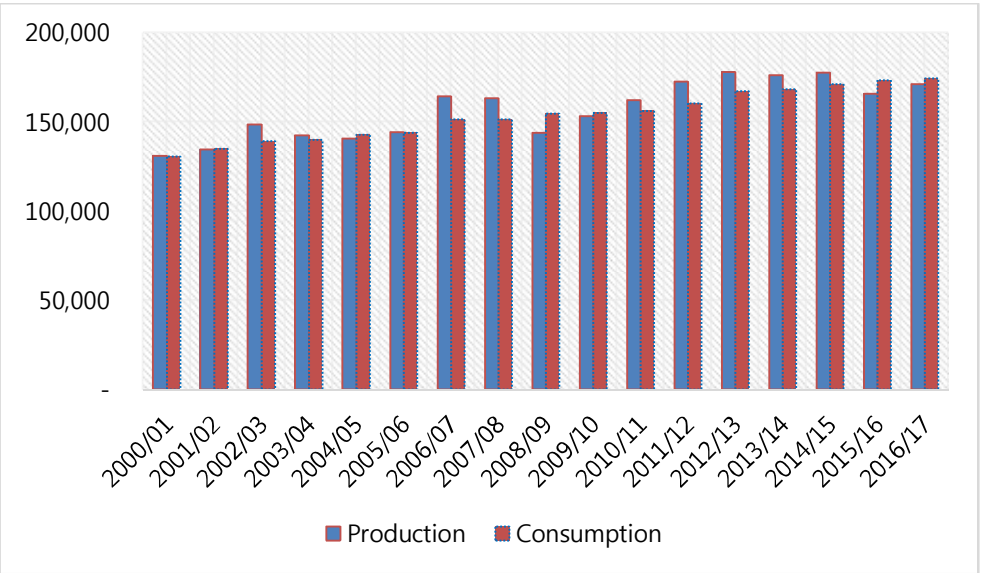
Source: Sugar and Sweeteners Yearbook Tables, USDA ERS (2016)

Meanwhile, world consumption of sugar continued to increase driven by rapid economic growth in emerging markets, rising demand for food and renewable biofuels. Far East (China, Korea, Japan), Indian Subcontinent and Sub-Saharan

Africa are three regions where income growth is much more important than population growth.

Figure 3. World sugar production and consumption change, FY2000/01 to FY2016/17

Unit: 1,000 MTRV

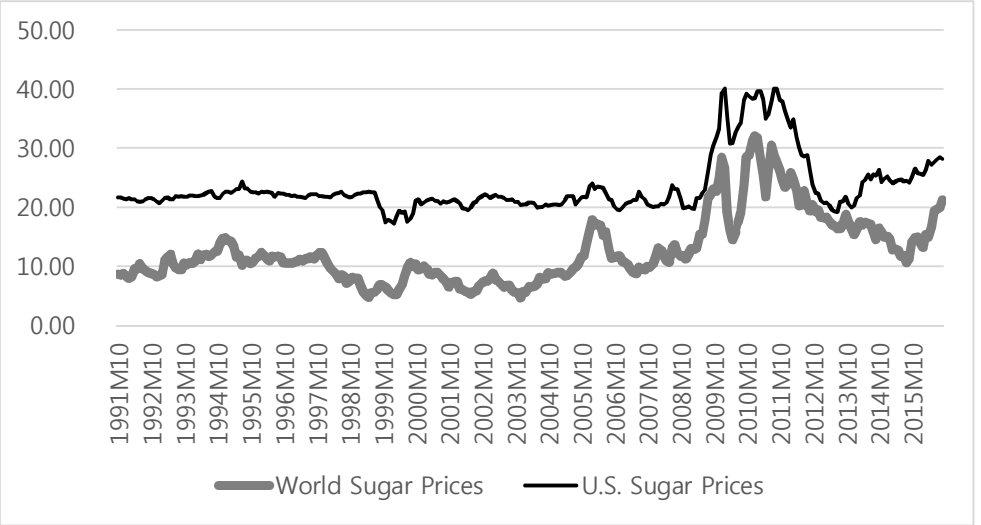


Source: Sugar and Sweetener Yearbook, USDA ERS (2017)

International sugar futures price showed downward trend after 2010, however, the prospect of global sugar production deficit has led to a price increase at the start of 2015/2016 season. Figure 4 provides the international sugar futures trends from FY1991/92 to FY2015/16.

Figure 4. World raw sugar prices (ICE Contract No. 11 nearby futures) and U.S. Raw Cane Sugar Prices (No. 14/16 U.S. raw cane sugar), Oct 1991-Sep 2016

Unit: cents per pound



Source: New York Board of Trade (2017)

Supply and demand are critical factors that drive the price movement of sugar as it is for other commodities. Global sugar production decreased by nearly 5 metric tons in 2015 given steady growth in consumption reflecting futures price increase as illustrated in Figure 3. Stock-to-use ratio began to fall in 2015 as well after four years of global stock surplus, world sugar futures is currently returning to a deficit phase. International Sugar Association (ISO) argues that the stocks still at comfortable levels and still reveals an optimistic view regarding sugar price though. However, FAO expects global sugar availability will continue to decline while world consumption in Asia and Africa will continue to rise rapidly.

2.2 A History of U.S. Sugar Program

Sugar industry in the United States has appreciated the market protection since 1789 when the U.S. Congress implemented the first tariff against the foreign sugar supplies (schmitz, Allen and Leu, 1984). Since then, domestic crop producers have been beneficiaries of an array of farm programs, but the level of support has varied over time and commodity to commodity. The U.S. Government controlled the domestic sugar market price in earnest under the Sugar Act from 1934 until it expired in 1974 (Barry, Angelo, and Buzzanell, 1990). The Sugar Act of 1934 provided a basis for determining the quantity restrictions on domestic sugar cane and beet production, and import quotas on sugar exporting countries to the United States. The government assigned the import quotas for each foreign supplier and set standby controls on sales of domestic sugar to keep the domestic price above the world level. Sugar policy support the sugar cane and beet grower to receive a minimum guaranteed price that is reported by USDA prior to each marketing year.

The 1981 farm act introduced a minimum non-recourse loan for sugar in which the government grants loan to cane and beet processors who in turn agree to pay minimum fee to producers (Lord, Gray, and Moore, 1993). In sugar program, unlike most other commodities providing direct payment such as corn, or cotton, the loan rate sets a price floor. According to Westcott and Hoffman (2001), commodities with marketing loans have market-clearing role because the price

floor prevents markets from clearing in times of surplus. The government is responsible by law to keep the domestic sugar prices above the loan rates so that the processors do not decide to forfeit their stocks to USDA Commodity Credit Corporation (CCC). Loan rates for raw cane sugar under farm acts rose from 16.75 cents per pound in 1981 to 18 cents in 1985, a level maintained until the 2002 act that cover through 2007 crops. Congress passed escalating price support loan rates in 2008 Farm Bill through 2012 to support producers with high input costs. Loan rates for sugar is continued with the same nominal support level – 18.75 cents per pound - under the 2014 Farm Bill which covers for the years of 2014-2018.

Meanwhile, the 1990 farm act established a provision that would limit the domestic sugar marketing allotments in which the government limits the quantity of domestically produced cane and beets sugar sold in the market. The provision established that if sugar import falls under 1.25 million tons, USDA announces an additional allotment for domestic refiners to release their stock (USDA ERS, Quarterly). Marketing allotments promise the minimum market share of foreign suppliers that hold the quota in the domestic market and maintain supplies of raw cane sugar for domestic refiners. Though costs and benefits of the sugar program still remain ongoing issue of debate, the program plays a role as the powerful roadblock to the U.S. sugar market liberalization.

2.3 U.S. Sugar Policy Instruments

The United States sugar industry is heavily protected under the federal sugar program that is currently administered by USDA under 2014 Farm Bill. To ensure that the policy operates at limited cost to taxpayers, domestic sugar crop growers and processors are subject to be regulated under the sugar program. The U.S. government currently run four pillars of sugar policy – price supports, domestic marketing allotments, import quotas, and feedstock flexibility program – to guarantee a minimum price for domestically produced sugar in the country (Sweetener Users Association, 2008).

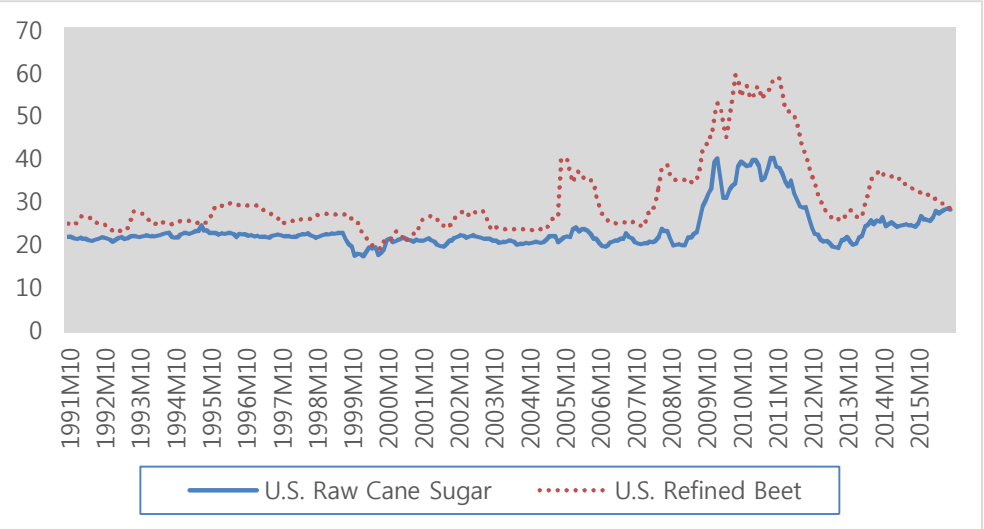
2.3.1 Price Supports through Loan Program

U.S. government provides minimum guaranteed price to cane and beet sugar producers through loans to sugar processors. The loan rates is the government's per unit[2] of production at which the government makes price support loans at harvest time to enable farmers to hold their crops for later sale (USDA ERS, 1996). National average rate and regional loan rates are announced each year by USDA CCC for cane and beets, respectively. Loan rates for refined sugar, whether derived from beets or cane, is usually higher than those of raw cane sugar because of the refined margin between two different forms.

[2] bushel, bale or pound (USDA ERS, 1996)

Figure 5. Historical Trend of U.S. raw cane and beet sugar prices, FY1991/92-FY2015/16

Unit: cents per pound



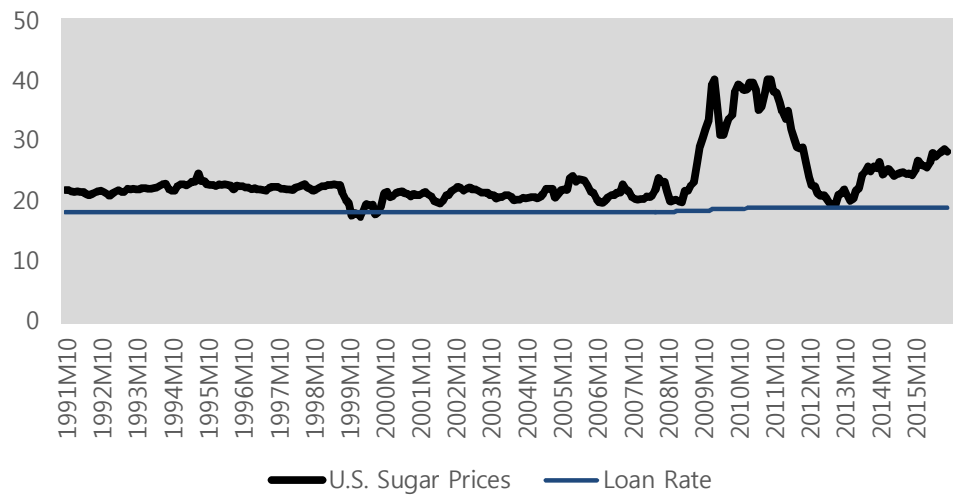
Source: Sugar and Sweetener Yearbook, USDA ERS (2017)

Despite that other commodity price supports are usually made to producers of farm commodities through direct payment, the government operates a price support scheme through a loan-rate program. The loan is given to the cane mills and beet processing plants that turns sugar crops into sugar, because the sugar collaterals collected by the government (CCC) needs to be stored for at least nine months in order to be available in the market, and the crop in natural form decays over time. Processed (Refined) cane and beets can stay longer in the storage. By law, processors who make minimum grower payments for the cane and beets growers are only eligible to receive the loans. Processors receive the loans usually for nine months and in turn, make sugar as the collateral and repay the loans with interest at maturity. In the event that market price falls below the

government loan rates, processors may forfeit their sugar to CCC. Forfeited sugar is not available in the market for at least nine months to avoid the excess of supply. Historically, the U.S. sugar price rarely was near or below the loan rates even though the rates were unchanged from 1985 to 2008. Figure 5 illustrates the historical U.S. market prices and average loan rates.

Figure 6. Actual and Minimum Support Prices (loan rates) of the U.S. Raw Cane Sugar, FY1991/92 - FY2016/17

Unit: cents per pound



Source: USDA Farm Service Agency (2017), Sugar and Sweetener Yearbook, USDA ERS (2017)

2.3.2 Domestic Marketing Allotments

In addition to the price support, the U.S. federal go ernment set the overall allotment quantity (OAQ) that limits the production and quantity of sugar sold by each processor in the domestic market. The policy does not directly restrict the

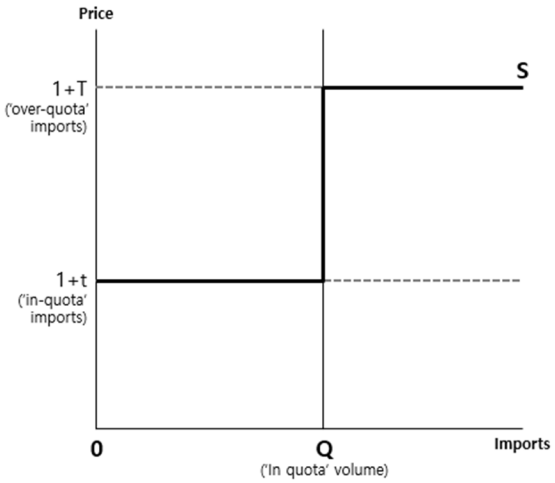
crop acreage however, it regulates the amount of farmer's delivery of crops to mills and processing plants and hence, indirectly controls the growers' output each year (Sweetener Users Association, 2008). OAQ for raw cane sugar is 45.65 percent of the overall quantity while 54.35 percent is allocated to refined beet sugar. Marketing allocations are also divided among 4 sugar-producing States (Florida, Louisiana, Hawaii, and Texas) based on the historical production of that states and processors. If a cane processor cannot make the assigned allotments, the share is redistributed to the other processors in the same State. Hawaii is the fourth sugar producing State in the U.S. which gets the share of 325,000 STRV each year (USDA ERS, 2016).

Main function of marketing allotments calculated by the government's complex mechanism is to provide the U.S. raw sugar producers and importers with the statutory minimum market share. Once primary allotment is announced, U.S. processors get the minimum 85 percent domestic market share as required by the Farm Bill, and the rest share go to foreign suppliers. USDA can reestablish allotments during the year as the domestic market condition (i.e. supply and demand) changes. Additional allotments normally go to domestic refiners and processors first, and any shortfall may be given to imports (Lord, Gray, and Moore, 1993).

2.3.3 Tariff Rate Import Quota (TRQ)

A two-tiered tariff rate quota (TRQ) also backs the high-priced U.S. sugar market. Prior to the start of each fiscal year (October 1 to September 30), the Secretary of Agriculture announces the preferential low-tier amount of sugar with lower import duty rates (so called "in-quota") for each TRQ countries. The imports entering above the quota portion face a much higher tariff rate (so called "over-quota") (USDA ERS, 2016). Technically, there is no quantity limit at higher over-quota tariff rate so that foreign sugar exporters will be eager to sell as much as possible in the high-priced U.S. market when the world price drops under the U.S. prices (Helmberger and Chavas, 1996). Figure 6 illustrates how two-tiered tariff rate quotas affect import demand.

Figure 7 Effects of TRQ on Import Demand



Source: Graph from Skully, David. Economics of Tariff-Rate Quota Administration (TB-1993). USDA Economic Research Service. Web. n. 2.

The raw cane sugar TRQ was introduced in 1982 and is allocated by the Office of the U.S. Trade Representatives (USTR) to 40 foreign countries based on their historical market shares between 1975 and 1981 when trade was relatively unrestricted (USDA ERS, 2017). Table 1 provides the U.S. sugar imports under TRQ. Quota holding countries do not necessarily reflect the current relative sugar exporting capability because the world production condition has been transformed over time since TRQ was established in 1982. In fact, some countries such as India, Haiti and Papua New Guinea did not even export sugars to the U.S. for many consecutive years. The quota system was modified in one way or another since then, particularly by the settlement of minimum import tariff allocation for quota holding countries after the Uruguay Round Agreement on Agricultural (URAA) of the World Trade Organization (WTO) in 1994. The U.S. agreed under the Agreement to allow import a minimum quantity of raw and refined sugar equal to 1.14 million metric tons, raw value (MTRV), or 1.256 STRV each year (USDA FAS, 2017).

Under WTO administration, TRQ is designed to consider the basic economic efficiency of price equates supply and demand. USTR forecasts of U.S. domestic sugar production, consumption and imports from large foreign suppliers such as Brazil and Mexico and pre-determines the sugar import allotments before each fiscal year begins. Current in-quota tariff for raw sugar is 0.625 cents per pound and the over-quota tariff is 15.36 cents per pound for raw sugar, 16.21 cents per pound for refined sugar (USDA ERS, 2016). The key objective of the import

quota policy is to maintain the domestic sugar price above the government loan rates for sugar so that the growers do not forfeit their sugar to CCC (Schmitz and Lewis, 2015). If the domestic sugar market is under-supplied on April 1 of the marketing year, USDA may establish additional in-quota portions. Selling sugars to the U.S. market at low-tier tariff provides financial benefit for foreign suppliers because U.S. market price is almost twice higher than the sugar quota-holding countries can receive in the world market (Sweetener Users Association, 2008). If the difference between domestic and world prices exceeds high over-quota tariff, the mechanism of a two-tier tariff system which technically make over-quota imports uneconomical to foreign exporters does not function anymore and the U.S. gets larger import volume than usual.

Table 1. U.S. Historical Import Quota Allocation and Fill Rate

Unit: MTRV, %

FY	Total Import Quota Allocation	Actual Imports	Fill Rate (%)
91/92	1,524,876	1,481,258	1.40
92/93	1,143,310	1,135,046	1.74
93/94	1,143,310	1,135,046	1.49
94/95	1,143,310	1,135,046	1.57
95/96	2,167,160	2,073,310	1.22
96/97	2,100,001	2,043,566	1.32

97/98	1,600,000	1,547,460	1.32
98/99	1,164,937	1,112,797	1.57
99/00	1,135,000	955,700	1.40
00/01	1,117,195	1,022,508	1.33
01/02	1,117,195	912,333	1.33
02/03	1,109,934	1,047,750	1.36
03/04	1,109,934	1,068,911	1.48
04/05	1,186,543	1,160,035	1.43
05/06	1,717,751	1,640,373	1.45
06/07	1,336,734	1,187,637	1.40
07/08	1,117,195	955,506	1.89
08/09	1,117,195	917,855	1.86
09/10	1,570,787	1,474,199	1.51
10/11	1,520,892	1,437,564	1.64
11/12	1,498,212	1,263,083	1.63
12/13	1,117,195	601,754	1.83
13/14	1,117,195	899,542	2.21
14/15	1,117,195	1,054,320	2.22
15/16	1,224,201	1,130,751	1.99

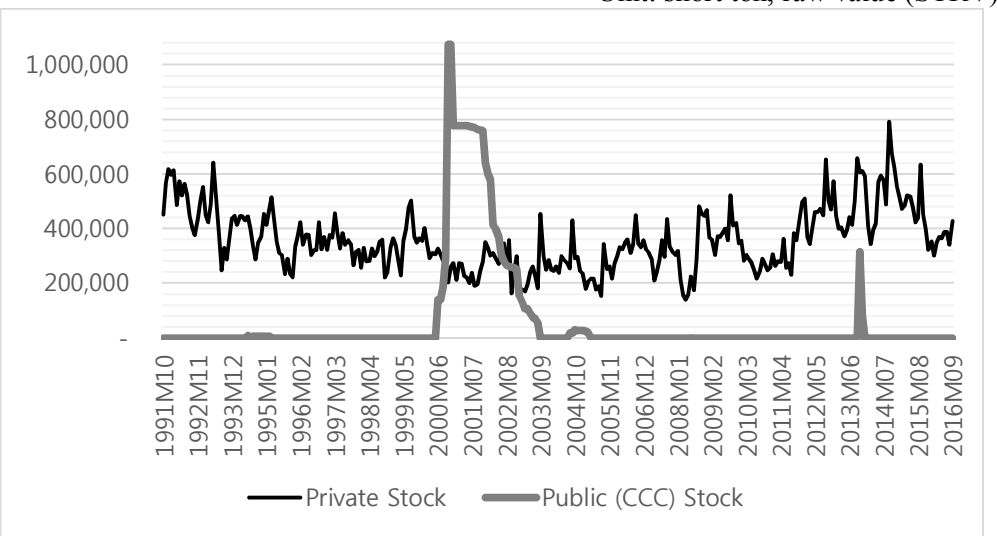
Source: Sugar and Sweetener Yearbook, USDA ERS (2017)

2.3.4 Feedstock Flexibility Program

Feedstock Flexibility Program (FFP) was created under the 2008 Farm Bill to encourage bioenergy plants to purchase sugar for ethanol production, if any. FFP is a new pillar of the U.S. sugar program to control domestic supply and run at no cost to the Federal Government by avoiding forfeitures to CCC (USDA CCC, 2011). Before the end of each fiscal year-end, CCC will estimate the amount of forfeited loan collaterals to purchase and offer to buy surplus sugar to bioenergy production usually at a taxpayer loss. Any bioenergy producers or marketers residing in the U.S. is eligible to purchase the forfeited sugar as a bioenergy feedstock, however, not obligated to buy them. Hence, the marketers will only be likely to buy the sugar for bioenergy production if it costs less than using corn as an input (Sweeteners Users Association, 2008). Sugars purchased for bioenergy feedstock is highly restricted by law for distribution in the market for human consumption except for an emergency market shortage (USDA CCC, 2011).

Figure 8. Private and Government Stocks for Raw Cane Sugar, 1991-2016

Unit: short ton, raw value (STRV)



Source: USDA FAS (2016)

3. U.S-Mexico Sugar Market Liberalization under NAFTA

3.1 U.S. Sugar Market Liberalization

For decades, the U.S. sugar industry has been successful at convincing the Congress to continue the various support strategies to shield the industry from any form of market liberalization. The U.S. sugar industry has been strongly lined up in opposition to bilateral and regional free trade agreements, believing that opening the U.S. market to foreign sugar will damage the market significantly. Sugar growers have continuously done a strong lobby to appeal their opposition

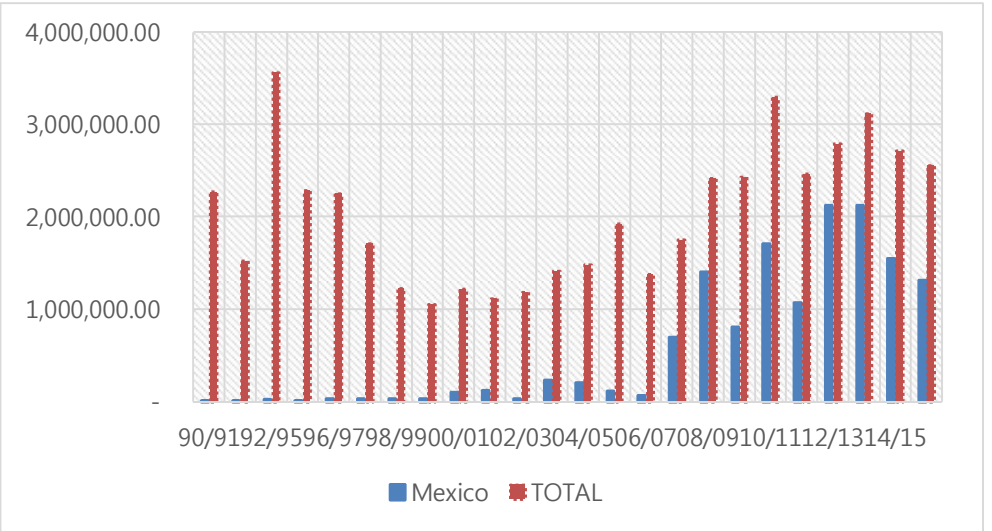
to the FTAs to the policymakers, not only the monetary contribution but also various form of anti-FTA crusades range from Congressional testimony, petitions, and press statements to commissioned studies (Forrer, Tussie, Díaz-Henderson, Funiciello, and Jancuk, 2005). Despite their effort to influence the trade policy, market liberalization was inevitable trend in global trade. U.S. has lowered trade barriers with the General Agreement on Tariffs and Trade (GATT) in 1947 followed by the Uruguay Round Agreements in 1994. The U.S. government has signed numerous regional and bilateral free trade agreements including the North American Free Trade Agreement (NAFTA), the Central American Free Trade Agreement (CAFTA-DR), and Australia-United States Free Trade Agreement (AUSFTA).

NAFTA is the free trade between Canada, Mexico, and the United States, signed by Canadian Prime Minister Brian Mulroney, Mexican President Carlos Salinas, and the U.S. President George H. W. Bush in 1993. This agreement went into effect as of January 1, 1994, created the world's largest free-trade area (U.S. Trade Representative, 2013). U.S. government believed that the country's agriculture sector with its large farms, heavy capitalization, and technological ability (e.g. crop processing, milling, etc.) will compete very well against Mexican farmers, but Mexico was capable of producing large amount of sugarcane with low input costs (McNiel, 2002). When unrestricted free trade between Mexico and the United States on sugar began in January 1, 2008 under the Side Agreement between two countries, Mexico gradually started to get a

hold on the U.S. sugar market (Jurenas, 2006).

Figure 9. United States Imports of Mexican Sugar, 1991-2016

Unit: short tons, raw value (STRV)



Source: Sugar and Sweetener Yearbook, USDA ERS (2017)

CAFTA is an agreement signed in 2004 between countries in Central America (Guatemala, El Salvador, Honduras, Nicaragua, and Costa Rica, and Dominican Republic). Dominican Republic later joined the agreement in 2005, officially became CAFTA-DR. The Central American countries agreed to remove their sugar tariffs over 15 years and the U.S. in accordance established annually increasing country-specific tariff rate quotas (TRQs), beginning at a total of 107,000 metrics tons, raw value (MTRV)[3] in 2006 and then increase 2,640

[3] 1 metric ton = 1.10231125 short tons.

MTRV per year (USDA ERS, 2016). However, the CAFTA-DR did not change high U.S. over-quota tariff (USTR, 2005). According to the policy brief from Office of the United States Trade Representative (USTR), increase market access of sugar into the U.S. from the CAFTA-DR countries take only small portion of the total U.S. sugar supplies and thereby, have only a little impact on destructing the U.S. sugar industry and relevant federal policy. In addition, U.S. under the CAFTA-DR is eligible to restrict imports if the U.S. sugar program is threatened, at its option, and instead offer equivalent benefits to applicable nations to offset their losses (USTR, 2005).

The United States also signed the Free Trade Agreement with its close ally Australia in 2004 and came into effect on January 1, 2005. U.S. and Australia under AUSFTA agreed to remain Australia's quota access for sugar. Australia's quota allocation in FY2017 is 87,402 MTRV (USTR, 2017).

3.2 Impact of NAFTA on U.S. and Mexico Sugar Markets

Prior to NAFTA's full implementation in 2008, Mexican sugar export to the United States was limited under TRQ (Schmitz and Lewis, 2015). Duty-free exports of Mexican raw sugar sugar permitted to the United States between 1994 and 2001 under NAFTA were 25,000 metric tons, raw value (MTRV) in which duty-free shipments in excess of the original 7,258 MTRV level (WTO minimum

import allocation) was only limited to Mexico's net sugar production surplus. The level of Mexican sugar imports into the U.S. gradually increased to 250,000 MTRV until the end of 2007. Yet, unlimited quantity of duty-free sugar was permitted following the sixth year of the Agreement if Mexico becomes a net surplus producer of both sugar and HFCS for two consecutive years. The original agreement was simply amended to include production minus projected domestic consumption to count Mexico's net surplus production. However, in the side letter reorganized the formula to add HFCS in Mexico's consumption side.

Starting in January 2008, Mexico and Canada was exempted from TRQ imposed on all countries under NAFTA. Mexican exports of sugar into the U.S. increased dramatically from 4% of total U.S. sugar imports in FY 2007 to almost 10% in FY2013 with the power to export unlimited duty-free sugar under NAFTA (USDA ERS, 2013). The U.S. producers did not realize the effect of NAFTA on internal market until mid-2012 because its effect on domestic prices was not high due to poor production in both the U.S. and Mexico plus several other external factors such as world commodity shock. However, U.S. domestic price reached almost the loan program support level.

3.3 Suspension Agreements on Sugar from Mexico

Unlimited duty-free access of Mexican sugar into the U.S. was suspended in December 2014 when the U.S. Department of Commerce decided to reestablish

the export limit from Mexico due to the antidumping (AD) and countervailing duty (CVD). U.S. Department of Commerce conducted the preliminary investigations on two subjects after the U.S. sugar industry suspected that the flood of Mexican sugar had harmed the domestic industry and filed the petition for duties (USDA ERS, 2016). More specifically, the U.S. sugar companies claimed that Mexican producers dumps raw sugar into the U.S. market under its fair value supported by the Mexican government subsidy plus low production cost. Washington in fact had to spend a significant amount of its budget to support internal sugar industry due to NAFTA's effect. The final suspension agreements which came into effect in January 2015 provided a framework for determining the maximum volumes and minimum price for Mexican sugar exports to the U.S. The AD agreement established floor prices to secure against the flood of Mexican sugar. The reference prices in the agreement were set at 22.25 cents per pound for raw sugar. The terms of CVD agreement included a maximum export limit based on the U.S. needs calculated by USDA's World Agricultural Supply and Demand Estimates (WASDE).

4. Price Models and Data

4.1 A Basic Price Model with Stocks and Government Programs

A framework for empirical analysis is derived from Labys' (1973) equilibrium model for competitive markets with inventories and the government support program. At market clearing or the perfect equilibrium, the price of good or services at which supply is equal to demand in the market. A supply function for annually produced crop consists of previous year's price[4] and other explanatory variables, while demand is a function of current price and previous year's price[5] and other exogenous variables. Especially, for crop used for livestock feeding, a historical price is important input factor for livestock production decision (e.g. quantity of inputs to buy) because such decisions are usually made ahead of time (Westcott and Hoffman, 1999). Stock (K) is simply the function of price, the government support price and other exogenous variables. The study by Westcott and Hoffman (1999) shows that government stocks give the positive effect on price while larger private stock drags down commodity price. Therefore, both the government (CCC) stock and private stock for cane sugar into the price equation enables to capture different stock effect on commodity prices. However, in case of U.S. sugar, the government stocks are only sold for the production of ethanol

[4] $\mathrm{S} = \mathrm{f}(p_{t-m}, z)$

[5] $\mathrm{D} = \mathrm{g}(p, p_{t-m}, z)$

and are not available in the marketplace as USDA Farm Bill[6] strictly prohibits the sale of CCC sugar for domestic human consumption (USDA ERS, 2017). The impact of the government stock on market price may be small and therefore, we only consider the private stock in the model. Labys (1973) adds that incorporating the government loan rate (LR) into the stock function enables to capture stockholding effect of the government loan program. On that account, the market equilibrium condition decides the price at which supply equals demand plus stock so that equilibrium condition is expressed as $\mathrm{S} - \mathrm{D} - \mathrm{K} = 0$ (Labys, 1973). It is assumed that the consumers have made their utility-maximizing choices given their budget constraints and information of the prices.

S denotes the supply, D denotes the demand, K denotes the private cane sugar ending stock, p is market price, LR is loan rates and z is a set of exogenous variables. All variables except previous year's price (p_{t-1}) are expressed in the current period value. Hence, the basic model structure based on the law of supply and demand takes a conventional form. In equilibrium, price is a direct inverse function of the stock and hence, the inverse stock function gives following price function with the loan program as shown in equation (2).

(1) $\mathrm{K} = \mathrm{h}(p, LR, z)$ (Stock function with the government loan program)

[6] The 2002, 2008, and 2014 Farm Bills, in specific.

(2) $p = h^{-1}(p_{t-1}, \mathrm{K}, LR, \mathrm{z})$ (Price equation; inverse stocks function)

4.2 Additional Consideration for Raw Cane Sugar Price Model

Some additional adjustments are included in the pricing model for raw cane sugar for more accurate estimation. The classical economic theory states that demand is function of price and income. As stated in previous literatures, U.S. per capita income ($INCOME$) is added to the price model to reflect positive effect of personal income on prices (Narayan, 2009). Refined beet sugar prices ($BEETP$) is included to represent the price of substitution goods influencing demand. Dummy variables to identify the effect of complete U.S. sugar market liberalization between 2008 and 2014 on the price function.

While supply and demand factors at large explains the bulk of the commodity prices movement, other issues such as political or regulatory changes, adverse climate change in major crop growing regions and market conditions holds the key in recent years (Hamilton, 2009). Dummy variables for commodity shock period examines the impact of world commodity or food price shock on inflation. It is expected to capture the direct impact of food and fuel price shocks on cane sugar prices and to provide the controlled effects of sudden price variation so that the estimation result would be less inaccurate. Lastly, we also incorporate predetermined endogenous variables (lagged variables) to model the dynamics of

the market prices that are captured by m lagged actual price. In addition, vector of m lagged market prices, $p_t = (p_{t-1}, p_{t-2}, \dots, p_{t-m})$, is added to give a convenient and flexible representation of dynamics in the model (Kim and Chavas, 2005). Selection of price lag order will be discussed later in the chapter.

Equation (2a) provides the raw cane sugar price consideration to basic pricing model suggested in the past literature.

$$\text{(2a)} \quad p = h^{-1}(p_{t-m}, \mathrm{K}, LR, BEETP, INCOME, Dum_{NAFTA}, Dum_{CSHOCK})$$

Final pricing model for raw cane sugar therefore consists of p_{t-m} for lagged raw cane sugar prices, K for private raw cane sugar stocks, $BEETP$ for refined beet sugar prices, $INCOME$ for U.S. personal income, Dum_{NAFTA} for the tariff-free sugar trade period between US and Mexico under NAFTA, and lastly, Dum_{CSHOCK} for the commodity price shock. These variables drive the U.S. raw cane sugar prices reflecting the effects of variables considered in the model.

4.3 An Empirical Analysis

Applying our model specification to U.S. raw cane sugar prices, we examine the effect of market liberalization on prices and its volatility in the presence of the strong federal government support to stabilize the market prices. Motivation for the research is the impact of the open trade with Mexico on domestic sugar market from 2008 to 2014 with the U.S. sugar program that was activated since 1930s. Our analysis relies on Generalized Least Squares (GLS) model that controls a possibility of systematic variation left in the error terms and allows for an efficient estimator under heteroscedasticity or autocorrelation of error terms.

In that respect we require to review number of the asymptotic properties of classical linear models should be discussed prior to the estimation to estimate the parameters in β in the regression with time series data. A time series data analysis is to use historical relationships to explain current and future behavior, believing that the future behaves similar to the past (Nielsen, 2005)

Augmented Dickey-Fuller (ADF) test is used to examine the unit root of the price series as it is specified in Table 3. The null hypothesis is that the series has a unit root (Dickey, D.A. and W.A. Fuller, 1979). Using the ADF test, it is found that raw cane sugar prices data is stationary at 5% level and most exogenous variables are stationary at 10% level.

Table 2. Augmented Dickey-Fuller (ADF) tests for non-stationarity of U.S. raw cane sugar prices

Variable	Augmented Dickey-Fuller			
	Test Statistics (τ)	1% Critical Value	5% Critical Value	10% Critical Value
P(t)	-2.641	-3.456	-2.878	-2.570
MacKinnon approximate p-value for P(t) = 0.0848				

Note: MacKinnon (1996) is one-sided p-value. N = 299.

One of the assumptions underlying the linear regression are errors must be serially uncorrelated with the explanatory variables. Estimators are no more efficient if autocorrelation is ignored in which can be easily ignored in time series analysis. Durbin-Watson (DW) test assesses the autocorrelation of residuals of the regression fit. There is no evidence for autocorrelation in the regression model, where the hypotheses usually considered in the DW test are illustrated below:

$$H_0 : \rho = 0$$

$$H_1 : \rho > 0$$

The test statistics for the Durbin-Watson test is $DW = \frac{\sum_{t=2}^{T}(e_t - e_{t-1})^2}{\sum_{t=1}^{T} e_t^2}$, where e_t is the residual associated with the observation at time t and T is the number of observations. While the test statistics value always ranges from 0 to 4, $d = 2$

indicates no autocorrelation (Durbin, 1951). DW test results give the test statistic of 2.0205 which rejects H_0 and concludes that errors terms are uncorrelated.

White Test is also implemented to test for possible heteroscedasticity, and the test rejected the null hypothesis of homoscedasticity at 1% level of significance. We can correct for it by utilizing the Weighted Least Squares that is BLUE (Best Linear Unbiased Estimator) if other classical linear assumptions hold. In this paper, we adjusted the standard errors for heteroscedasticity with Generalized Least Squares estimation.

To incorporate a market dynamics in the model, enough lags need to be included so that further lags of dependent variable (P_t) do not matter in explaining P_t. A lag selection order of the AR process (m) in equation (3) are decided to be m = 1 based on the selection of Akaike information criterion (AIC) (McQuarrie and Tsai, 1998). Since there are no autocorrelations in the errors as indicated in Durbin-Watson test results, we have dynamically complete time-series regression models (Woodridge, 2016).

Table 3. Lag selection order criteria for raw cane sugar prices

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-361.56				5.1e-07	2.54367	2.57417	2.61979
1	11010.1	22743	36	0.000	4.4e-41*	-75.9041*	-75.6906*	-75.3712*
2	10752.7	-514.81	36	.	3.2e-40	-73.9151	-73.5491	-73.0017
3	10658.1	-189.24	36	.	7.6e-40	-73.0527	-72.5342	-71.7587
4	10673.1	30.071	36	0.746	8.4e-40	-72.9491	-72.2781	-71.2745
5	10617.8	-110.72	36	.	1.5e-39	-72.3584	-71.5349	-70.3032
6	10666.3	96.933	36	0.000	1.3e-39	-72.4862	-71.5102	-70.0504
7	10671.1	9.5983	36	1.000	1.6e-39	-72.3118	-71.1833	-69.4954
8	10670.3	-1.5752	36	.	2.0e-39	-72.0987	-70.8177	-68.9017
9	10637.5	-65.542	36	.	3.1e-39	-71.6643	-70.2308	-68.0867
10	10680.8	86.57*	36	0.000	2.8e-39	-71.7563	-70.1702	-67.7981

Note: Endogenous: raw cane sugar price, stocks, beet prices, income, loan rates and time trend. N = 289.

Given that econometric basis, we consider the log-log form of the estimable regression model for U.S. raw cane sugar price for observations $t = 1, 2, \ldots, 300$,

$$(3)\quad Ln(P_t) = \alpha + \beta_1 Ln(P_{t-1}) + \beta_2\, Ln(S_{t-1}) + \beta_3\, Ln(BEETP_t) + \beta_4\, Ln(INCOME_t) + \beta_5\, Ln(LR_t) + \beta_6 NAFTA + \beta_7 SHOCK + \beta_T \mathrm{TT} + \beta_{Q1}\mathrm{Q1} + \beta_{Q2}\mathrm{Q2} + \beta_{Q3}\mathrm{Q3} + \varepsilon_t$$

where β is a $k \times 1$ vector of parameters to be estimated and ε_t is an error term. The model we consider has market dynamic specification involving lagged dependent variable ($Ln(P_{t-1})$) in exogenous variables. Stocks for cane sugar are available in two different forms (government stocks and the private stocks) in the market, however, we only include the private stock and the lagged private stocks ($Ln(S_{t-1})$) that is owned by cane refiners in the model[7]. It is expected that higher private stocks in previous period should lower the market price and decrease price volatility. U.S. refined beet prices ($Ln(BEETP_t)$), per capita income ($Ln(INCOME_t)$), and dummy for commodity price shock ($SHOCK$) are control variables to clarify the relationship between key variables and the dependent variable. Loan rates ($Ln(LR_t)$), and dummy for sugar market liberalization between the U.S. and Mexico ($NAFTA$) are key variables that are of primary interest in the analysis. We anticipate that the loan rates and the effect of the

[7] During the sample period, domestic raw cane sugar price was at or below the government loan rates only 1.67 percent of the time, therefore, the government owned stock exists for very limited time and price censoring effect due to the government support should be minimal.

market liberalization which allows unlimited access of sugar into the U.S. market from Mexico will affect the expected value of domestic sugar price and its movement significantly. In specific, increase in loan rates would decrease both the expected market price and volatility. We expected that an existence of market liberalization would decrease the expected market price while increase the volatility. Lastly, we include in time varying instrument variables (x_t) a time trend TT to apply the effects of long-term trends and quarterly dummy variables (Q_1,Q_2, Q_3) to capture a seasonality effect in the regression model.

Prior to the model implementation, it may be necessary to test whether the powers of the variables are adequate to use in the analysis. Ramsey RESET Test (Regression Equation Specification Error Test) is used for possible missing variables. An incorrect functional form can lead to biased coefficient estimates and for instance, using a simple linear model "lin-lin" form would not be appropriate if the dependent variable and each independent variable exhibit a non-linear relationship. Ramsey RESET Test result failed to reject the null hypothesis of specification at 10% significance level which states that the functional form is correctly specified. In that respect, dependent and independent variables in the suggested econometric model are demonstrated in natural logarithms form which allows to easily evaluate elasticities.

Time series data are often characterized by random and rapid changes in which are defined to be volatile. This study also investigates the impact of the private stocks and key policy variables on the price volatility underlying the change in

the trend of economic series based on the residual of mean regressions. Economists widely use the standard deviation of logarithmic prices for measuring volatility is since it is a unit-free measure (Gilbert and Morgan, 2017). The log standard deviation is approximately equal to the coefficient of variation (CV) for low levels of volatility. Volatility throughout the paper is referred to as the conditional heteroscedastic model in which conditional variance depends on time. The model specification provided in equation (4) can be viewed as providing basic relationship between volatility of $Ln(P_t)$ and market liberalization, lagged stocks, and the price support loan rate.

$$(4)\ \sigma_t^2 = \exp[\gamma_0 + \gamma_1 S_{t-1} + \gamma_2 NAFTA + \gamma_3 LR_t + \mu_t]$$

It is generally supposed that lagged stocks (S_{t-1}) would be the important source of price variability in agriculture. Higher stocks would reduce volatility so long as stocks are accumulated in times of excess supply and released when there is an excess demand. On the other hand, lower stocks will tend to have negative impact on volatility due to the high-risk exposure for short supply and excess demand. An increased supply for sugar into the U.S. market under NAFTA agreement ($NAFTA$) is expected to increase the volatility, while rise in loan rates (LR_t) would have the stabilizing effects on the price volatility because higher price supports guaranteed for the producers help stabilizing the price movement.

4.4 Data

Price model is estimated with a sample of 300 observations of U.S. raw cane sugar prices to investigate the impact of open trade with Mexico on the raw cane sugar price. Data and Sources are illustrated in Table 5. The analysis is applied to monthly No. 14/16[8] U.S. raw cane sugar prices from October 1991 to September 2016 on sugar marketing year (October 1 to September 30) basis. Price data series are based on reports of the USDA Economic Research Service (ERS) Sugar and Sweeteners Yearbook, which provides a comprehensive set of statistics for U.S. and international sugar and sweetener production, consumption, and trade.

[8] The No. 14 raw sugar U.S. domestic contract was replaced by the No. 16 raw sugar contract as No. 14 futures contract expired on August 10, 2009. The last No. 14 futures contract listed was the September 2009 contract and the first No. 16 futures listed for the trading was January 2009.

Table 4. Data and Sources

Variable		Unit	Sources
Dependent	U.S. Raw Cane Sugar Price	cents per pound	USDA Economic Research Service (ERS)
Independent	U.S. Refined Beet Sugar Price	cents per pound	Milling & Baking News
	U.S. Producer Price Index (PPI) for corn sweeteners and sugar	1982=100	U.S. Bureau of Labor Statistics
	U.S. Consumer Price Index (CPI) for corn sweeteners and sugar	1982-84=100	U.S. Bureau of Labor Statistics
	U.S. Private Cane Sugar Stocks	short tons, raw value (STRV)	USDA Farm Service Agency (FSA)
	U.S. Average Sugar Loan Rates	cents per pound	USDA Economic Research Service (ERS)
	U.S. per capita Income	billions of dollars	Federal Reserve Economic Data, Federal Reserve Bank of St. Louis (FRED)
	Dummy for Sugar Market Liberalization with Mexico through NAFTA	2008.1-2014.12 = 1, Otherwise = 0	USDA Economic Research Service (ERS)
	Dummy for Commodity Price Shock	2008-2010 = 1, Otherwise = 0	USDA Economic Research Service (ERS)

We concentrate on 1991 to 2016 to capture the pre-post effect of complete sugar market liberalization between the U.S. and Mexico through North American Free Trade Agreement (NAFTA) on raw cane sugar prices. The nominal price data series measured in current U.S. dollars are transformed to real values using the U.S. Producer Price Index (PPI) for corn sweeteners and sugar to adjust for inflation.

Refined beet sugar prices[9] are also sourced from USDA ERS who derived monthly prices from the weekly quotation reported by Milling and Baking News. Refined beet sugar prices are also adjusted by PPI to make it appropriate for the analysis. Private ending stocks data are based on Historical Sweetener Market Data from the USDA Farm Service Agency (FSA). Private inventories are the monthly ending stocks held by cane refiners who receives the sugar loan under the domestic sugar program while the public stocks are those collected as loan forfeitures by USDA's Commodity Credit Corporation (CCC) under the U.S. sugar program. Private cane stocks released in the market are directly managed by marketing allotments. USDA CCC announces the separate marketing assistance loan rates each fiscal year for raw cane sugar and refined beet sugar. CCC reports national weighted average loan rates for raw cane sugar and the rates for 4 different growing states: Florida, Hawaii, Louisiana, and Texas.

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[9] There is no futures market for U.S. refined beet sugar, but a price range for wholesale Midwest refined beet sugar is weekly quoted in Milling and Baking News. Data are simple average of the lower end of the range of weekly quotations for days in that month (USDA ERS, 2017).

Nominal average loan rates are deflated by the PPI index for the month.

Monthly U.S. Personal Income data comes from the Federal Reserve Bank of Saint Louis (FRED) economic database and is seasonally adjusted annual rate measured in billions of dollars. Income data series is adjusted based on U.S. Consumer Price Index (CPI) for sugar and sweetener. Sugar import quota and import tariffs from Mexico to the U.S. were completely lifted as of January 2008 under NAFTA until the suspension agreements were signed between the Department of Commerce and the Government of Mexico in December 2014. Hence, tariff-free sugar trade period between US and Mexico under NAFTA are coded as 1, and 0 otherwise. U.S. domestic commodity market was periodically affected by world commodity price shocks between February 2007 and December 2012 causing cane sugar price to rise dramatically in these periods. Dummy variable takes the value 1 during the price shock and 0 otherwise to control the effects of unpredictable price change. Summary statistics are shown in Table 6.

Table 5. Summary statistics

Variable	Unit	Mean	SD	Min	Max
Private stocks (S_{t-1})	short tons, raw value (STRV)	357735.4	112839.4	139849	791703
U.S. refined sugar beet price ($BEETP_t$)	Cents per pound	.238	.032	.176	.338
U.S. personal income ($INCOME_t$)	Billions of dollars	10191.01	3192.945	5139.5	16169.1
USDA sugar loan rates (LR_t)	Cents per pound	.147	.023	.092	.201
Dummy for Sugar Market Liberalization with Mexico through NAFTA ($NAFTA$)	2008.1-2014.12 = 1, Otherwise = 0	.29	.455	0	1
Dummy for Commodity Price Shock ($SHOCK$)	2008-2010 = 1, Otherwise = 0	.24	.428	0	1
N	298				

5. Estimation Results

5.1 Estimation Results for Raw Cane Sugar Equation

The empirical analysis consists of estimating two models in Equations (3) and (4) by generalized least squares as applied to the U.S. raw cane sugar market. The

parameter estimation for the role of sugar programs and NAFTA on mean price change between FY1991 and FY2016 is provided in Table 7.

Table 6. Parameter Estimates for Generalized Linear Regression: U.S. Raw Cane Sugar Prices, Oct 1991–Dec 2016 (dependent variable = Raw Cane Sugar Prices)

Definition	Coefficients	Standard Error
Intercept for the mean price equation	2.44***	(.614)
Lagged price of raw cane sugar (P_{t-1})	.897***	(.025)
Lagged private stocks (S_{t-1})	-.015**	(.007)
U.S. refined sugar beet price ($BEETP_t$)	.059***	(.016)
U.S. per capita income ($INCOME_t$)	-.251***	(.064)
USDA sugar loan rates (LR_t)	.100***	(.022)
Dummy for Mexico-US tariff-free period ($NAFTA$)	-.005	(.007)
Dummy for Commodity Price Shock ($SHOCK$)	.014*	(.007)
Time Trend (TT)	.001***	(.000)
Seasonal Dummy for 1st Quarter (Q1)	.001	(.005)
Seasonal Dummy for 2nd Quarter (Q2)	.003	(.005)
Seasonal Dummy for 3rd Quarter (Q3)	.004	(.005)
F	313.99	
R^2	0.92	

Note: Asterisks indicate statistical significance at the * 10%, ** 5%, and *** 1% levels. N = 298

The estimation result showed that all variables except NAFTA and seasonality variables are statistically significant. In both mean and variance specification, we investigated the effects of lagged private cane refinery stocks (S_{t-1}). Estimation result indicated that the private stock is found to have negative effects on the mean price with one percent increase in stock would lower the market prices by 0.02 percent. Larger supply pushes the market price down in general so that the estimation result corresponds to this general idea. In case of U.S. sugar, the government sugar program administers the quantity of sugar an individual refiner is allowed to sell through marketing allotments. Therefore, the effect of the stock on the mean price is not large since the amount of refined sugar in private storage is indirectly controlled from the production level. Consequently, the estimation result for price variance equation showed that private stock is not statistically significant because the supply of domestically produced sugar is completely controlled by the sugar program and does not impact the internal price volatility.

USDA loan rates for cane sugar (LR_t) are found to have a positive effect on mean price in which one percent increase in support price pushes the expected prices by 0.10 percent. Loan rates provide a price floor or the government guaranteed minimum support. During a sample period, the price support program was activated only a few times because U.S. sugar price rarely fall below or near the loan rates. With the flood of cheap Mexican sugar comes into the U.S. market, floor price guarantees the minimum price for producers and therefore, it acts as a successful price shifter for sugar. In the price variance specification, the

coefficient of loan rates is negative and statistically significant, indicating that the price support program has a price stabilization effect. Since U.S. sugar prices below the support level is censored, higher loan rates close the price variance gap and hence reduce the price risk for both producers and refiners when cheap Mexican sugar are poured into the market.

We observed the effects of NAFTA on both mean and variance specification to investigate the impact of market liberalization for U.S. sugar. We expected that NAFTA significantly harmed the U.S. market by lowering the average market price and increasing the price volatility because Mexico is the cheapest sugar supplier to the U.S. and increased chance of unexpected supply should increase the price volatility. In the mean price specification, parameters for NAFTA is not significant. Though free and increased access of Mexican sugar began in 2008, Mexican sugar industry suffered for the poor production due to the erratic weather. Global price shocks (e.g. oil price shock, commodity price shocks) is also found to have a spill-over effect on U.S. commodity prices to skyrocket, hence, NAFTA did not cause large immediate effects on the domestic prices until the second quarter of 2012. It is reasonable to find that NAFTA's impact on mean price is statistically insignificant. On the other hand, parameters for NAFTA in variance specification is highly significant as presented in Table 8. The estimation results indicate that the price volatility was exceptionally widened during the NAFTA period, indicating that the elimination of import quota for Mexico weakened the strong government intervention for U.S. sugar price and its

supply. World sugar market is usually highly volatile compared to the U.S. sugar market since domestic industry is insulated from global sugar price fluctuations caused by weather disruptions, commodity and oil price shocks. Thus, it is found that sugar program weakened the price stabilization effect during NAFTA due to abolition of import quotas on Mexico between 2008 and 2014.

Parameter estimates for the lagged price show the dynamic characteristic of U.S. cane sugar price. We found that one percent increase in the lagged price is associated with a 0.90 percent increase in mean price, indicating that the effects of price shocks in the past continues into current period and carries the price upward. In commodity futures market, the historical prices help to provide a long-term market perspective to market players (i.e. speculators and hedgers). Agricultural commodity is sensitive to the movements of expected prices that is built based on the historical patterns because the most common way to trade the commodities is through a futures contract. Refined beet and cane sugar both creates an identical end-product so that beet price increase would provide positive effect on cane prices. Estimation results show that if refined beets price increases by one percent then cane sugar prices would increase by 0.06 percent. Meanwhile, one percent rise in per capita income gives negative impact on the price by 0.25 percent. Time trend parameter is positive and statistically significant indicating upward long-term trend in price movements.

Table 7. Parameter Estimates for variance: U.S. Raw Cane Sugar Prices, Oct 1991–Dec 2016

	Parameter	Coefficients	Standard Error
γ_0	Intercept for the mean squared deviation equation	5.96e-06	(.000)
γ_1	Private stocks (S_{t-1})	-1.41e-06	(1.24e-06)
γ_2	Dummy for Mexico-US tariff-free period (Dum_{NAFTA})	3.25e-06***	(1.23e-06)
γ_3	USDA sugar loan rates (LR_t)	-7.06e-06**	(3.35e-06)
F		12.82	
R^2		0.12	

Note: Asterisks indicate statistical significance at the * 10%, ** 5%, and *** 1% levels. N = 299.

5.2 Discussion

Prior to NAFTA, the U.S. government administered the supply of sugar into the domestic market completely. Though the U.S. is obligated to allow minimum import quantity access each year under WTO and signed for numerous bilateral and regional free trade agreements, the sugar program mechanisms successfully have helped to mitigate against a supply shock.

In general, opening a domestic market can stabilize domestic prices by varying export and import markets so that stabilize the internal commodity price. A closed economy solely depends on domestic production for sugar, thus reliance on internal production may bring significant price shock in case of natural disasters, and political shocks. In contrast, our estimation results indicate that the price volatility was exceptionally widened during the NAFTA period. Coefficients of variation (CV) for cane sugar prices ex-ante and ex-post NAFTA also support our estimation result as illustrated in Table 9. CV during NAFTA (0.258) is nearly four times larger than pre-NAFTA (0.444), but it immediately decreases to the previous level after the trade between Mexico and the U.S. was deferred under anti-dumping suspension agreement (0.058). Despite the addition of import markets (i.e., Mexican sugar market), it is evident that NAFTA weakened the stabilization effect of sugar program.

Table 8. Coefficient of variation (CV) for U.S. raw cane sugar ex-post NAFTA

Period	CV
Pre-NAFTA (1991-2007)	0.055
NAFTA (2008-2014)	0.258
Post-NAFTA or Trade Suspension Period (2015-)	0.058

6. Concluding Remarks

A system of protectionist policies for sugar in the United States called the sugar program has successfully administered the price of domestic sugar prices with a main goal to lower sugar production and to raise the market price above U.S. government minimum support price and world sugar prices. Current sugar program is operated under 2012 Farm Bill with three principal mechanisms: price support loan program, tariff rate quota (TRQ), and marketing allotments. The program has been successfully achieved its intended goal to protect the domestic industry until the North American Free Trade Agreement (NAFTA) became fully implemented for sugar in 2008. Since its full implementation, Mexican sugar exports into the United States significantly increased from 64,035 STRV in FY2006/07 to 2,123,944 STRV in FY2013/14 (USDA ERS, 2017). Unlimited access to Mexican sugar under NAFTA affected U.S. prices significantly with the flood of cheap sugar making the domestically produced sugar uncompetitive.

This paper has investigated econometrically the price stabilization effects of the U.S. sugar program in the midst of complete sugar market liberalization with Mexico using monthly time-series data for the period from October 1991 to September 2016. We particularly attempted to investigate the effectiveness of each sugar program components on domestic price stabilization during NAFTA. Our framework for the analysis is derived from an equilibrium model for

competitive markets with inventories and the government program referred in Labys' (1973) and Westcott and Hoffman (2001)'s research. Mean and variance models consist of private cane sugar stock, market supply and demand factors, and policy variables measuring sugar program mechanisms and the effects of NAFTA. We utilize the Generalized Least Squares (GLS) estimation method to allow for a possibility of time-varying volatility reflected by the heteroscedasticity of the error terms.

The estimation results indicate that the price volatility was exceptionally widened during the NAFTA period. The NAFTA agreement made it difficult for the U.S. government to hinder cheap sugars coming into the market and it significantly affected market price fluctuation. In particular, the government loan rates responded negatively and significantly to price volatility while private stocks had little effect on lowering volatility. Because the federal government sets the quantity of sugar to be produced and processed in the refinery, the stocks only have little impact on price fluctuation.

Prior to the full implementation of NAFTA, the U.S. government administered supplies of sugar into the domestic market completely, hence the impact of foreign sugar on internal market prices was small. Three price support tools (marketing allotment, price floor, and tariff quotas) of the U.S. sugar program successfully stabilized domestic prices by anticipating the need of the market and by controlling the supply effectively in the pre-NAFTA period. However, with

Mexican sugar flooding into the U.S. market under NAFTA, these price supports did not effectively work as a price stabilization tool and increased market price volatility. Preliminary estimation results suggest that price volatility is positively related to a NAFTA dummy variable, which implies that the weakening of price support programs results in an increase of price volatility despite the addition of import markets (i.e., Mexican sugar market). In addition, higher price volatility during the NAFTA is also evidenced by the coefficient of variation (CV). CV for the NAFTA period (0.258) is nearly four times larger than that of the pre-NAFTA period (0.055) and returns to its previous level (0.058) after the U.S. re-established the import quotas on Mexican sugar in 2015.

There are several limitations in this analysis. The relatively simple structure of the estimated price models may be improved to use more precise model applications and with more critical supply and demand factors. Another limitation is that our analysis does not consider CCC stocks in the model because the government stocks are only sold for ethanol production as USDA Farm Bill strictly prohibits the sale of CCC sugar for domestic human consumption. Our analysis could be further extended by considering the relationship between the price volatility of U.S. sugar and High Fructose Corn Syrup (HFCS) that is a significant replacement for sugar in soft drinks. Demand for HFCS is rapidly increasing in Mexico and other countries with rapid growth because it is cheaper than using sugar. While a bilateral sugar dispute between Mexico and the U.S. is

unresolved, a large amount of the U.S. produced HFCS are still exported into Mexico every year. Further research, therefore, is needed to estimate the role of substitutes on price volatility and the market stabilization.

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국문초록

정부 설탕 정책의 가격 안정성 효과 분석: NAFTA를 통한 시장개방을 전후를 중심으로

서울대학교 대학원

농경제사회학부 농업·자원경제학전공

김채리

미국은 1930년대부터 여러 가격 안정정책을 통해 자국 원당가격이 국제 평균가격보다 2배 가까이 높도록 유지시키면서 국제 상품가격 변동성에도 적은 영향을 받을 수 있도록 보호해왔다. 특히, 이러한 안정정책의 일환으로 수입할당제를 활용하여 외국산 사탕수수와 사탕무 수입을 제한하는 등 철저한 보호무역을 펼쳐왔다.

그러나 WTO 체재와 국제적인 시장개방 추세 하에서 북미자유무역협정(NAFTA)이 체결됨에 따라, 멕시코산 원당이 2008년 1월부터 규제 없이 대량 수입되어 미국 원당가격은 국외요인에 크게 영향을 받기 시작하였다. 이러한 배경 하에서 2007년 미국 전체 수입량의 4% 수준이었던 멕시코산 사탕수수는 2014년 10%까지 급증하였다. 그러나

미국설탕협회(ASC)가 멕시코산 설탕이 국가보조를 통해 멕시코 시장가격보다 낮은 가격으로 수입되고 있다고 이의를 제기하면서 2015년부터 멕시코는 무관세 설탕수출권리를 상실하였다.

본 논문은 NAFTA에 의한 미국 원당시장 개방 하에서 정부의 설탕프로그램(U.S. Sugar Program)이 원당 가격안정에 얼마나 효과적이었는지 계측하였다. 일반적으로 국내시장이 완전 개방되면 시장 공급자가 다양화되어 수급조절이 용이해지므로 국내 가격 안정화에 도움을 줄 수 있다. 그러나 Chavas and Kim (2006), Johnson (1975)과 Srinivasan (2001) 등 다수의 선행연구는 국내시장이 개방될 경우 국내 시장의 가격 변동성이 증가한다고 주장하였다. 반면, Yang, Haigh, and Leatham (2010)는 국내 시장개방이 국내 가격에 미치는 영향은 품목별로 상이하다고 주장하였다. 따라서 설탕프로그램의 가격안정성 효과를 분석하기 위해서는 개방 하에서 운영되는 제도(국내 판매량 할당, 가격지지, 관세할당제)가 원당의 평균가격과 가격변동성에 어떤 영향을 주는지 살펴볼 필요가 있다.

본 연구는 USDA ERS의 1991년 10월부터 2016년 9월까지의 월별 미국 사탕수수 원당(No. 14/16 U.S. Raw Cane Sugar)의 월별 가격자료를 이용하였고, 시계열 자료에서 발생할 수 있는 잔차의 이분산성을 고려한 일반최소자승(Generalized Least Squares (GLS)) 모형을 사용하였다. 비(非)정부 사탕수수 원당 재고량, 정부지지가격과 NAFTA 더미변수 등을 주요 변수로 활용하여 설명변수가 미국 사탕수수 원당의 평균가격에 미치는 영향이 유의미한지 먼저 파악한 후, 평균가격 모형의 잔차를 이용하여 각 설명변수가 분산에 미치는 영향을 계측하였다.

평균 및 분산모형 추정결과, 시장 개방 하에서 미국 원당 가격의 변동성이 크게 증가한 것으로 나타났다. 이는 변이계수(CV)가 NAFTA 체결 전보다 체결 후에 약 4배 증가한 것과 일치한다. 한편, 시장개방 기간 동안 사탕수수에 대한 정부의 가격지지제도는 평균 시장가격을 증가시키지만 분산은 감소시켜 가격안정에 효과적인 것으로 나타났다. 그러나 국내 판매량할당제도를 반영하는 비(非)정부 사탕수수 원당 재고량은 시장개방 하에서 가격안정효과가 미미한 것으로 분석되었다.

주요어 : 사탕수수 원당, 가격안정성효과, 미국설탕정책, NAFTA

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Appendix

Appendix 1. Expected Volatility (E($\hat{\sigma}_t^2$)) of U.S. Raw Cane Sugar Prices, Oct 1991–Dec 2016