Journal of Agricultural and Applied Economics, 41,3(December 2009):777–789

Production Response to Increased Imports: The Case of U.S. Sugar

P. Lynn Kennedy and Andrew Schmitz

This paper considers how the welfare of U.S. sugar producers can be affected by the use of production controls in the presence of rising sugar imports and falling sugar prices, taking into account the negative externalities associated with U.S. sugar production. Even if production controls are used, producer welfare can be affected negatively under rising imports.

Key Words: import quota, production quota, supply management, U.S. sugar

JEL Classifications: F13, F14, Q17

Under competitive conditions, increased imports result in import-competing producers cutting production as prices fall. As a result, producers suffer economic losses. There are many cases in which producers do not act competitively in response to increased imports. For example, the Canadian supply-management system runs counter to a competitive supply model in which producers practice supply management through production controls in the presence of imports (Katz, Bruneau, and Schmitz, 2008; Schmitz, 1983; Schmitz, 2008; Schmitz, Coffin, and Rosaasen, 1996). In theory, at least, producers maximize profits subject to various levels of imports (Vercammen and Schmitz, 1992). Supply management has also been discussed with reference to the U.S. sugar industry and was implemented under the Payment-in-Kind sugar program. With rising domestic and world prices in early 2000, in part due to natural disasters, the discussion over the use of sugar-production controls died. However, in 2007, with falling sugar prices coupled with rising imports, the discussion over the use of production controls in sugar had again surfaced. U.S. sugar producers, for example, were being pressured through the sugar portion of the North American Free Trade Agreement (NAFTA), which allowed for free trade in sugar by the end of 2008. U.S. imports of sugar from Mexico have increased sharply since 2005. The question the industry must consider is: Can U.S. producers offset the losses from increased imports by restricting production? Even if they could, there are major issues to consider before producers would opt for a supply-management scheme. Regardless, certain producers would never opt for such a scheme.

For internationally traded commodities, import-quota rents can take various forms. They can go to the government in the importing country, to producers, to private importers, or to exporters. For example, for sugar exports to the United States, quota rents go to sugar exporters, but only to those with preferential status (Schmitz, Schmitz, and Seale, 2003). A related question that the industry must consider is:

P. Lynn Kennedy, Crescent City Tigers alumni professor, Louisiana State University and LSU AgCenter, Baton Rouge, LA. Andrew Schmitz, Ben Hill Griffin Jr. eminent scholar and professor, University of Florida, Gainesville, FL.

We would like to thank two anonymous reviewers for their useful contributions to this paper. Special thanks go to Carol Fountain and H. Carole Schmitz for editorial assistance. This article has been approved for publication by the Louisiana Agricultural Experiment Station, Baton Rouge, LA.

What will happen to export-quota rents in the presence of domestic production controls? In this paper, we discuss how export-quota rents and U.S. producer welfare would be affected by the use of production controls in the presence of rising sugar imports and falling sugar prices, taking into account negative externalities associated with U.S. sugar production. Even if production controls are used, producer welfare can be affected negatively under rising imports. We also show in this paper that export quota rents increase under supply management.

Theoretical Considerations

The U.S. sugar program supports the price of sugar in the United States through the operation of a tariff-rate quota (TRQ). The TRQ on sugar in the United States is set to guarantee a domestic sugar price of 18 cents per pound on raw sugar and 22.9 cents per pound on sugar refined from sugar beets.

The TRQ is based on two different sugar quota rates. The first quota rate is essentially zero and allows for a basic minimum access to the domestic market. The second quota-rate is typically prohibitive. In Figure 1, the excess supply and excess demand of sugar in the U.S. market are depicted using the small country assumption. The kinked excess-supply curve (*abcd*) follows the world price p_w at quantities below the fixed import quota $q*$ and moves to the world price plus the over-quota tariff $p_w + t$ at levels greater than $q*$. The effective excess-supply curve is discontinuous at the minimum-access quantity, which results in the domestic market price of p_q. The goal of the U.S. sugar program is to provide support to the domestic sugar price. Given a fixed import quota of $q*$, the over-quota tariff leads to the domestic price being capped at $p_w + t$ in the small country case. If conditions were to lead to the difference in domestic and world prices being equal to or greater than this out-of-quota tariff, then imports would expand beyond those of the initial TRQ of, for example, $q*$.[1]

[1] Under the small country assumption, the out-of-quota tariff provides a cap on the U.S. domestic price.

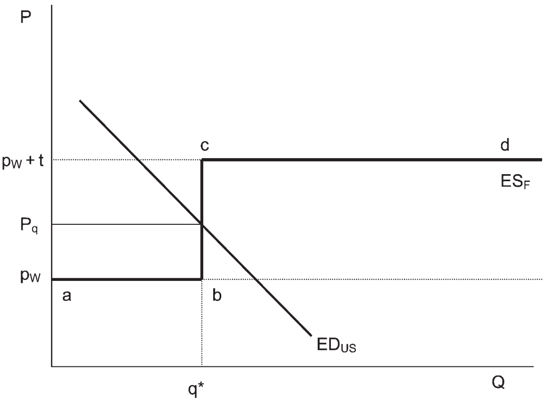

Figure 1. Tariff-Rate Quota Program for U.S. Sugar

In addition to the TRQ, the Food, Conservation, and Energy Act of 2008 includes a nonrecourse loan program to provide a floor for domestically produced raw sugar from sugarcane. The operation of this particular loan program is complicated by the Dole Amendment of the 1985 U.S. Farm Bill, which requires that the sugar program be conducted at no cost to the U.S. Treasury. One result of the Dole Amendment is that payments under the loan-rate provisions for sugar are made using payments-in-kind.

We present a trade model that contains both U.S. import quotas and domestic-production controls (Figure 2). Domestic demand is given by the curve D^0, and domestic supply is given by S. (Here it is assumed there are no negative externalities associated with production, but this assumption is relaxed later.) Under free trade, the domestic border price is p_b, domestic production is Q_1, and domestic consumption is Q_2. Imports total $Q_2 - Q_1$.

Suppose, however, as in the case of U.S. sugar, that free trade is not attainable. Imports are restricted by the use of quotas. First, we restrict imports to $Q'_2 - Q'_1$ by means of an import quota. This restriction of imports increases the domestic price to p_1, increasing domestic production to Q'_1, and decreases domestic consumption to Q'_2. Producers gain producer surplus p_1p_bab while consumers lose consumer surplus p_1p_byx (Vercammen and Schmitz, 1992).

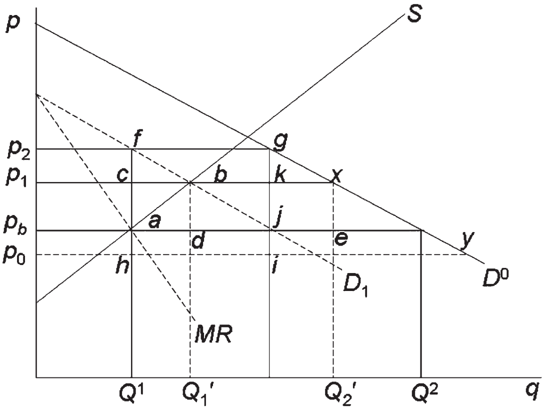

Figure 2. Import Quotas and Domestic Production Controls

What happens if producers practice supply management in the presence of import quotas? Consider an import quota in the amount of $Q'_2 - Q'_1$. Domestic producers now face the demand curve D^0. For domestic producers to maximize profits, the production quota is set at that point where the marginal revenue curve *MR* equals the supply curve *S,* which results in domestic production of Q_1. (Note: we have used two instruments—import quotas and production quotas). By imposing production controls, producers gain area $p_1cfp_2 - abc$ relative to their gain from import controls alone. The total gain for producers is the entire area p_bafp_2 from joint production and import controls.

Consumers lose the entire area p_bygp_2 as a result of the combined production and import controls. The absolute size of the loss depends on the size of the import quota in place. Importers gain area *fckg* as a result of production controls. However, if the quota depresses world prices below p_b (e.g., p_0), then the importers earn additional rents of *ahij*. Generally, where this type of model applies, the quota rents reside with importers who are usually processors of the product being imported (Vercammen and Schmitz, 1992). However, in the case of sugar, the exporters receive the quota rents.

The availability of import-quota rents gives importers/exporters incentives for rent-seeking behavior because import quotas have a value equal to *fajg* under the small-country assumption and a value of *fhig* under the large-country case. This value arises because importers, for example, buy a product at p_b and sell it in the domestic market at p_2. Alternatively, exporters sell at p_2, at a supply price of p_b.

With the framework of Figure 2, one can model the outcome of various import quota levels. For convenience, we illustrated only a quota of size $Q'_2 - Q'_1$. By varying the size of imports, one can show that, at a certain level of imports, supply management can no longer compensate for the erosion in producer rents from freer trade.

The above outcome is essentially a producer-monopoly solution in which producers have market power through the ability to set prices or they are given market power through legislation that allows them to practice supply management (this is the case in Canadian supply management). Our results assume competitive behavior on the part of U.S. sugar producers, and consider what the impact would be under a sugar supply-management scheme introduced in response to rising imports. This article is motivated by the fact that increased sugar imports depress internal U.S. sugar prices. To maintain the U.S. sugar-producer-support prices at current levels at no cost to the government, the problem of how to deal with overproduction can arise.

In our modeling efforts, we consider the joint effect of increased imports and the introduction of production controls. There are cases when the loss to producers from freer trade can be more than offset by the gains from the introduction of supply management. However, this does not always need to be the case. Consider Figure 3f, where we compare autarky to trade equal to $q_1 - q_2$. The autarky price and quantity are p_1 and q_1, respectively. Suppose imports are allowed in the amount of $q_1 - q_2$ at a price p_3. Producers lose p_1afp_3 under competitive conditions. Clearly, producers lose even more if free trade is allowed, given a free trade price of p_0. With supply management, producers restrict output to q_3 and charge price p_2.

However, could the introduction of production controls in the presence of an increase in imports offset the loss that occurs under competitive conditions? Given an import quota of $q_1 - q_2$, producers lose $acd - p_1dep_2$ relative to no trade; without production controls, producers lose p_1afp_3 (Figure 3). Even with supply management, producer welfare remains below that of no trade, since acd is greater than p_1dep_2. If free trade is allowed, then producer welfare will be further reduced, even in the presence of supply management. This can be seen with reference to the free trade, supply-managed demand curve D_2. One can also compare trading situations. For example, it is possible to trace out the effects of allowing imports to increase from $q_1 - q_2$ to the free-trade level with production restricted through supply management.

Empirical Results

Previous analyses have modeled the impact of increased sugar-import quotas on the U.S. sugar market. For example, Petrolia and Kennedy (2003) use *Modele Internationale Simplified de Simulation* to analyze increases in the U.S. sugar TRQ to determine the impact of increased exports from Cuba and Mexico. While their framework allows for the use of production and import quotas to be used as policy instruments, it does not allow for the simultaneous use of both.

For the purposes of this analysis, a partial-equilibrium framework is developed to determine the profit-maximizing production quota given a specific import-quota level. Our model considers the United States as a small country relative to the rest of the world.[2] Three sectors are utilized within this framework: domestic production, imports, and domestic consumption. Domestic consumption Q_C is comprised of products produced domestically, Q_S and/or imported Q_M, such that:

(1) $$Q_C = Q_S + Q_M,$$

where Q_M is determined exogenously by the domestic government through their choice of TRQ level.[3]

In the absence of the ability to restrict supply, the domestic price will adjust to changes in Q_M, which will result in producers adjusting Q_S based on their supply function, and consumers adjusting Q_C based on their demand function. A market-clearing price will be achieved when Q_S and Q_C, resulting from the new Q_M, meet the conditions in Equation (1).

The welfare implications of supply management are examined by allowing producers to restrict production (Figures 1 and 2). Through the restriction of domestic supply, producers are able to increase the price they receive for their product. By producing at a point where marginal revenue equals marginal cost, producers are able to maximize profit.

Simulations are conducted in this analysis for alternative quota levels and for alternative supply and demand elasticities using Microsoft Excel. Given the observed supply and demand quantities at the base-price level, linear supply and demand is used to determine: (1) the market clearing equilibrium in the absence of supply management given a specific import quota and (2) the profit-maximizing production quota and corresponding equilibrium given a specific import quota. The domestic quantities and prices are then used to calculate the

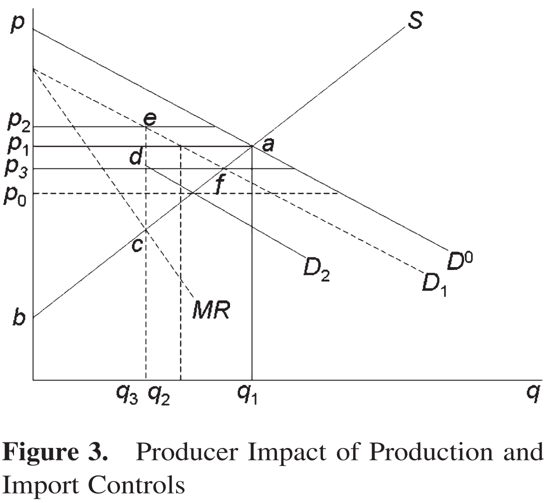

Figure 3. Producer Impact of Production and Import Controls

[2] The United States accounts for approximately six percent of the world centrifugal sugar demand, and less from a supply perspective. Given this, our analysis uses the small-country assumption for the United States in modeling the welfare impacts of the import quota.

[3] The TRQ employed by the United States uses a tariff of zero for all in-quota imports, and a prohibitive over-quota tariff structure. The over-quota tariff becomes non-prohibitive, given a sufficient decrease in world price and/or an increase in U.S. price.

respective changes in producer and consumer surplus resulting from each scenario.

The base-level raw-sugar quantities and prices used in these simulations are based on 2004/2005 data obtained from the Sugar and Sweeteners Outlook (United States Department of Agriculture, 2007). Total U.S. demand was 9.079 million metric tons (mmt), which was comprised of 7.597 mmt from domestic production and 1.482 mmt from imports. The status quo price of raw sugar was U.S. 22.92 cents per pound ($505.30 per metric ton, mt).

The base-level-import quota, used as the status quo in this analysis, was 1.482 mmt. Various scenarios were developed, based on alternative policy strategies, to expand the level of imported sugar by expanding the import quota. The minimum expansion was based on Dominican Republic - Central American Free Trade Agreement (DR-CAFTA) provisions of an additional 100 thousand metric tons (tmt). Other scenarios considered include expansion of the base-level-import quota by 500; 1,000; and 2,000 tmt.

The literature shows U.S. own-price sugar supply elasticities ranging from 0.10 to 0.70 (Lopez, 1989; Lopez, 1990; Tyers and Anderson, 1992). Gardiner, Roningen, and Liu (1989) used an aggregate own-price sugar supply elasticity of 0.50, which we adopt in this analysis. Demand elasticities, in the literature, range from −0.10 to −0.60 (Gardiner et al., 1989; Lopez, 1989; Lopez, 1990; Tyers and Anderson, 1992; Uri and Boyd, 1999). Based on these estimates, we employ demand elasticities of −0.10, −0.30, and −0.60.

Import-Quota Levels

We show the impacts of alternative import-quota levels when the sugar industry does not practice supply management (Table 1). In these scenarios, the domestic market price adjusts to achieve equilibria where domestic production plus imports equal domestic consumption. These results show consistently that an increase in the total import quota causes: (1) the market-clearing price to decline, (2) market-clearing production levels to decrease, (3) producer surplus to decrease, and (4) consumer surplus to increase. For

Table 1. Alternative U.S. Sugar Import Quota Levels Under Market Clearing Conditions

Demand/Supply		Total Import Quota (1,000 mt)				
Elasticities		1,482	1,582	1,982	2,482	3,482
−0.1/0.5	Market clearing price (cents/lb)	22.92	22.43	20.49	18.05	13.18
	Market clearing production (1,000 mt)	7,597	7,516	7,193	6,790	5,983
	Producer surplus ($1,000)	2,879,586	2,798,440	2,482,523	2,107,127	1,421,337
	Consumer surplus ($1,000)	22,942,179	23,039,776	23,432,236	23,927,472	24,933,480
−0.3/0.5	Market clearing price (cents/lb)	22.92	22.57	21.16	19.41	15.89
	Market clearing production (1,000 mt)	7,597	7,539	7,306	7,015	6,432
	Producer surplus ($1,000)	2,879,586	2,820,944	2,590,890	2,313,476	1,792,495
	Consumer surplus ($1,000)	7,647,393	7,717,906	8,003,193	8,367,083	9,119,132
−0.6/0.5	Market clearing price (cents/lb)	22.92	22.67	21.68	20.44	17.96
	Market clearing production (1,000 mt)	7,597	7,556	7,392	7,186	6,775
	Producer surplus ($1,000)	2,879,586	2,838,172	2,674,763	2,475,555	1,792,495
	Consumer surplus ($1,000)	3,823,697	3,873,484	4,075,856	4,336,066	4,943,681

example, given a demand elasticity of −0.3 and a supply elasticity of 0.5, producer rents fall by roughly $1 billion for an increase in imports of 2.0 mmt to 3,482 tmt. On the other hand, consumers gain roughly U.S. $1.5 billion from expanded imports.

A more elastic demand elasticity tends to lessen the decrease in the domestic price and to lessen the decrease in domestic production, resulting in smaller losses in producer welfare. Consider the results presented in Table 1, holding the supply elasticity constant at 0.5. The initial domestic price, given the status quo import quota of 1,482 tmt, remains at 22.92 cents per pound. Adoption of an import quota in the amount of 1,982 tmt results in a decrease in the domestic price to 20.49 cents per pound based on a demand elasticity of −0.1, but falls to only 21.68 cents per pound with the more elastic demand elasticity of −0.6. Correspondingly, production decreases to 7,193 tmt with a demand elasticity of −0.1, but only decreases to 7,392 tmt with the more elastic demand elasticity of −0.6. At the same time, producer surplus decreases from U.S. $2.88 billion to U.S. $2.48 billion with the smaller demand elasticity but decreases to only U.S. $2.67 billion with the larger demand elasticity.

Supply Management

The impact of alternative import quota levels when the U.S. sugar industry utilizes supply management is shown in Table 2. In these scenarios, the domestic industry selects a production level to maximize producer surplus, given a specific import quota level (the model developed in Figure 2). Depending on the supply and demand elasticities used in the scenario, increasing the import quota reduces a producer's ability to extract rents. Eventually, a point is reached at which supply management cannot compensate for increases in the import quota. For example, for a demand elasticity of −0.3 and a supply elasticity of 0.5, supply management is able to improve producer welfare even if the import quota increases from 1.48 mmt to 3.48 mmt. However, for a demand elasticity of −0.6 and a supply elasticity of 0.5, producer welfare is reduced with an import quota of

Table 2. Alternative U.S. Sugar Import Quota Levels and Supply Management Strategies

Demand/Supply		Total Import Quota (1,000 mt)				
Elasticities		1,482	1,582	1,982	2,482	3,482
−0.1/0.5	Optimal production quota (1,000 mt)	6,735	6,635	6,235	5,735	4,735
	Domestic price (cents/lb)	44.69	44.69	44.69	44.69	44.69
	Change from SQ Mkt clearing PS ($1,000)	3,183,328	3,123,187	2,869,319	2,522,047	1,727,716
	Change from SQ Mkt clearing CS ($1,000)	−4,151,160	−4,151,160	−4,151,160	−4,151,160	−4,151,160
−0.3/0.5	Optimal production quota (1,000 mt)	5,010	4,910	4,617	4,433	4,065
	New domestic price (cents/lb)	44.69	44.69	43.79	41.13	35.81
	Change from SQ Mkt clearing PS ($1,000)	1,959,702	1,876,614	1,533,840	1,114,035	325,644
	Change from SQ Mkt clearing CS ($1,000)	−3,737,234	−3,737,234	−3,607,370	−3,211,210	−2,363,312
−0.6/0.5	Optimal production quota (1,000 mt)	4,801	4,764	4,617	4,433	4,065
	New domestic price (cents/lb)	34.68	34.42	33.35	32.03	29.37
	Change from SQ Mkt clearing PS ($1,000)	725,317	674,055	471,521	224,010	−252,162
	Change from SQ Mkt clearing CS ($1,000)	−1,992,502	−1,955,480	−1,803,685	−1,605,605	−1,181,656

Note: SQ is Status Quo.

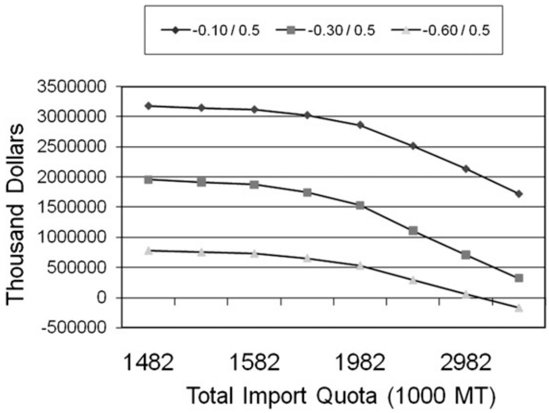

Figure 4. Change in Producer Surplus from Status Quo Market Clearing Conditions Given Alternative Supply Elasticities

3.48 mmt even in the presence of supply management, given the initial starting point of 1.48 mmt coupled with production controls.[4] However, without supply management, the loss to producers from increased imports is roughly four times as great when comparing Tables 1 and 2.

The Erosion of Industry Rents

Figure 4 demonstrates the erosion of the industry's ability to achieve its initial welfare status as the import quota increases. We compare the change in producer surplus under profit-maximizing supply management for alternative import-quota levels in relation to the producer surplus obtained with the initial import quota and market clearing conditions. As shown in Figure 4, scenarios are analyzed in which the demand elasticity is held constant at 0.5, utilizing alternative demand elasticities of −0.01, −0.3, and −0.6. The ability of a country to improve its producer welfare through supply management decreases as the import quota level increases, with a decreased ability to enhance producer surplus as the demand elasticity becomes more elastic. This figure indicates that, given a demand elasticity of −0.6, the United States loses the ability to use supply management to achieve its status quo producer surplus level as the import quota approaches three mmt.

In contrast, consumer welfare increases as the total import quota is expanded. Figure 5 demonstrates the improvement in consumer welfare for three alternative demand elasticities as the import quota expands from 1,482 tmt. An interesting point related to this figure stems from production limitations due to the over-quota tariff. Throughout the scenario using the −0.1 demand elasticity and at lower import quota levels of the −0.3 demand elasticity scenario, the use of supply management is limited by the provisions of the over-quota tariff; the use of supply management to increase the domestic price beyond 44.69 cents per pound results in increased access of foreign sugar, which undermines the supply management program. The profit maximization strategy under supply management of producing up to the point where additional imports could enter the United States under the over-quota tariff keeps consumer welfare constant as the import quota expands. When the over-quota tariff is not an issue in determining the supply management production level, consumer welfare improves as the import quota increases.

Sugar versus High-Fructose Corn Syrup Demand

In the above analysis, we assume that there is no shift in the basic relationship between the

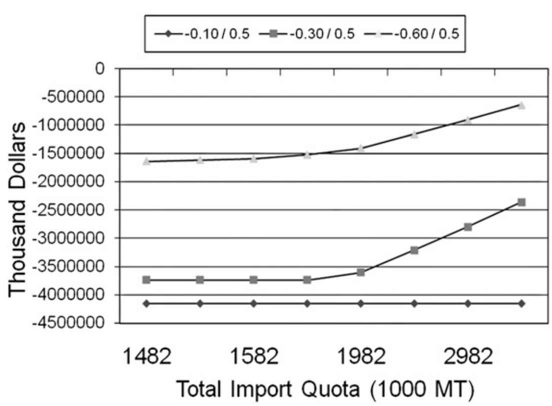

Figure 5. Change in Producer Surplus from Status Quo Market Clearing Conditions Given Alternative Demand Elasticities

[4] See Appendix Figure A for calculations based on demand and supply elasticities of −0.6 and 0.5.

demand for sugar and the demand for High-Fructose Corn Syrup (HFCS). Historically, roughly 50% of the U.S. sweetener market has been made up of HFCS. However, this may no longer be the case as the demand for sugar might increase in the United States relative to HFCS. This is in large part because of the sharp increase in corn prices in 2007. Corn is the key ingredient in the production of HFCS. Because of the price increase for corn, HFCS prices have also increased and, for the first time in history, HFCS prices are equivalent to sugar prices (Figure 6). If the suggested increase in demand for sugar relative to HFCS does occur, then at least part of the increase in sugar imports from Mexico will be absorbed in the sweetener market without depressing sugar prices (Castillo, Bucaram, and Schmitz, 2008).

Limitations

There are two important issues not dealt with in the above analysis: (1) the environmental impacts of freer trade and (2) the benefits from sugarcane processing. A claim is often made that negative externalities are associated with sugar production, especially with sugarcane production. We show the results from production controls if indeed there is a divergence between private and social marginal production costs. Including these externalities as costs to the industry will result in an upward shift in the supply curve. It is important to note that our analysis hinges on the assumption, rather than on empirical evidence, that there are negative externalities.

In Figure 7 we illustrate the impact of negative externalities in relation to the U.S. sugar program. The private marginal cost curve of the sugar industry is S_P while the corresponding social marginal cost is S_S. An increase in imports from $q_1 - q_2$ to $q_3 - q_4$ lowers producer welfare, but results in a positive societal gain of *abcd*. In addition, under supply management, output is restricted to q_m, and results in an additional welfare benefit of *dcef.*

Table 3 presents results considering both a 10% and 20% increase in costs, given alternative import quota levels. As expected, both scenarios show a decrease in the optimal production quota as the supply curve moves to the left. This results in an increase in domestic prices.

The trends within each of the three scenarios are consistent, with an increase in the import quota resulting in a decline in domestic price levels and decreased domestic

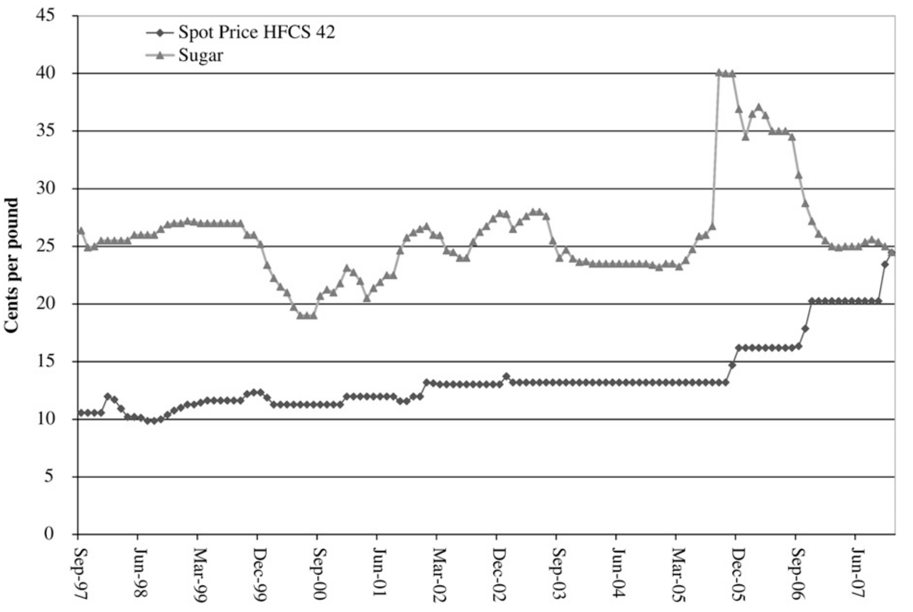

Figure 6. HFCS-42 and Sugar Prices (cents per pound); September 1997–September 2007

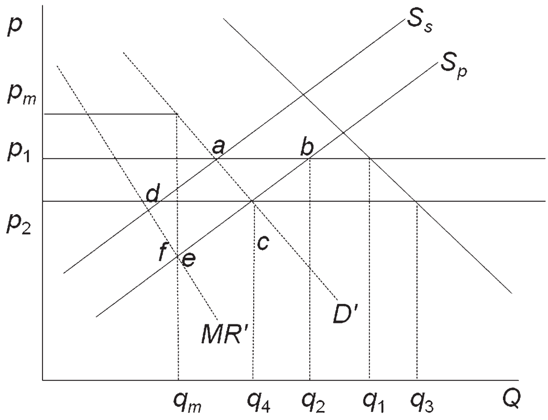

Figure 7. Trade and Negative Externalities

production. This occurs whether or not supply management is employed. What is striking is the difference between scenarios. In the case that does not account for negative externalities (the initial supply schedule), prices are shown to be lower and production levels are shown to be higher than in the alternative scenarios. As producers account for various negative externalities in their production decisions, including environmental degradation, there is a tendency toward decreasing production levels. At the same time, domestic prices are higher across-the-board as producers account for additional costs of production.

The data presented in Table 3 show how the socially optimal production levels deviate from the private outcomes. From this it is possible to measure the additional producer gains that are generated from negative externalities. Also, it is clear that a move toward freer trade is consistent with environmental groups' concerns over environmental degradation, given that increased market access results in decreased domestic production.

Processor Rents

In our empirical work, we estimate the impact of U.S. policy changes on sugar-producer welfare, but we ignore the sugar-refining sector. The majority of U.S. imported sugar is in raw form and is further processed in the United States by the sugar companies, Imperial and Domino. Added sugar imports result in more processing for these two. However, concerning the U.S. sugar sector in total, an increase in raw sugar imports occurs along with a decrease in domestic sugar production. But the combination of imports and domestic production available for processing increases (Table 4),

Table 3. Optimal U.S. Sugar Production Quota Levels and Corresponding Price Data with Alternative Supply Schedules, Supply Elasticity of 0.5, and Demand Elasticity of −0.6

	Total Import Quota (1,000 mt)				
	1,482	1,582	1,982	2,482	3,482
	Initial Supply Schedule				
Profit maximizing production quota (1,000 mt)	5,385	5,356	5,239	5,094	4,802
Domestic price with production quota (cents/lb)	32.23	31.93	30.74	29.25	26.26
Market clearing production level (1,000 mt)	7,597	7,556	7,392	7,186	6,775
Market clearing price (cents/lb)	22.92	22.67	21.68	20.44	17.96
	10% Cost Increase				
Profit maximizing production quota (1,000 mt)	5,169	5,141	5,029	4,889	4,610
Domestic price with production quota (cents/lb)	33.14	32.83	31.62	30.10	27.07
Market clearing production level (1,000 mt)	7,174	7,136	6,980	6,786	6,398
Market clearing price (cents/lb)	24.70	24.44	23.41	22.12	19.55
	20% Cost Increase				
Profit maximizing production quota (1,000 mt)	4,970	4,943	4,835	4,701	4,432
Domestic price with production quota (cents/lb)	33.97	33.67	32.44	30.90	27.82
Market clearing production level (1,000 mt)	6,796	6,759	6,612	6,429	6,061
Market clearing price (cents/lb)	26.29	26.02	24.96	23.63	20.97

Table 4. U.S. Production, Imports, and Product Available for Processing under Alternative Supply Management Strategies

Demand/Supply Elasticities		Total Import Quota (1,000 mt)				
		1,482	1,582	1,982	2,482	3,482
−0.1/0.5	Domestic production (1,000 mt)	6,735	6,635	6,235	5,735	4,735
	Imports (1,000 mt)	1,482	1,582	1,982	2,482	3,482
	Product for processing (1,000 mt)	8,217	8,217	8,217	8,217	8,217
−0.3/0.5	Domestic production (1,000 mt)	5,010	4,910	4,617	4,433	4,065
	Imports (1,000 mt)	1,482	1,582	1,982	2,482	3,482
	Product for processing (1,000 mt)	6,492	6,492	6,599	6,915	7,547
−0.6/0.5	Domestic production (1,000 mt)	4,801	4,764	4,617	4,433	4,065
	Imports (1,000 mt)	1,482	1,582	1,982	2,482	3,482
	Product for processing (1,000 mt)	6,283	6,346	6,599	6,915	7,547

with the exception being the case where the over-quota tariff is a constraint. Therefore the amount of processing activity increases for processors of cane sugar. Because the total volume of U.S. processed sugar increases, processors gain regardless of decreasing, constant, or increasing returns to scale, with gains being greatest with increasing returns to scale. Impacts vary according to firm size, with the industry made up of processors ranging from small sugar beet factories to very large sugarcane processors.

If sugar production is restricted, processors lose unless they can increase sugar processing from additional imports of raw sugar. But this would be possible only for processors of cane sugar, not processors of beet sugar. Given this, the welfare of beet processors would decline. The U.S. sugarcane industry is highly integrated. Two sugar entities in Florida, Flo-Sun, Inc. and U.S. Sugar Corporation, are integrated vertically from the farm to the refinery level (Moss and Schmitz, 2002). As such, these sugar producers maximize rents from both production and from sugar refining. This is not the case, however, for producers in Louisiana, where there is less integration between sugar producers and raw-sugar-mill owners. Thus there are three cases to consider when interpreting our empirical results: (1) beet processors lose from various forms of production controls, (2) nonintegrated cane processors gain since the loss due to decreased domestic processing is more than offset by the increase in the processing of imported sugar, and (3) integrated cane processors gain from added processing and from their production activities. Therefore, in aggregate, the processing sector gains in this framework, implying that the overall welfare effects of supply management are understated.

Conclusion

Many producers of import-competing commodities are pressured by government policies that allow for freer trade. We have demonstrated that supply management in sugar can lessen the impact of increased sugar imports into the United States. However, there is a point at which supply management can no longer compensate producers for the negative impacts of increased import quotas. Although this analysis has shown that supply management could be beneficial to the U.S. sugar industry to mitigate the impact of increased imports, we recognize that many U.S. sugar producers would likely not support a Canadian-type supply-management system for sugar. On the other hand, such a system would likely be supported by environmental groups. However, under a supply-management system, there are many difficult issues, including the allocation of production quotas among producers.

It is important to reiterate the sensitivity of our results to the price elasticity of demand.

The demand elasticity chosen impacts the ability of supply management to mitigate producer losses stemming from an expansion of the import quota. Under inelastic demand conditions the ability of the industry to respond to increased imports is restricted because of the over-quota tariff. In addition, the choice of demand elasticity used is critical with respect to the relationship between supply management and the over-quota tariff. In scenarios involving less elastic demand elasticities (-0.1 and -0.3) the profit maximizing production quota must be set in such a way as to support price up to a certain level and yet not exceed the price which triggers increased imports using the over-quota tariff. The range of demand elasticities used in this analysis is consistent with demand elasticities used in previous studies and provides useful information, which industry and government can use in evaluating this policy tool.

It is also important to note that while the processing sector as a whole will benefit because the availability of sugar for processing increases, the impact of individual components of the sector will be mixed. Gains to integrated and nonintegrated cane processors will be offset to some extent by losses to beet processors. Future analysis should provide an empirical counterpart to our previous discussion on the impact of policy on the sugar processing sector. Our empirical analysis focuses on the producer sector only in that the rents calculated in this analysis are of a Ricardian nature.

[Received April 2008; Accepted May 2009.]

References

Castillo, M.J., S. Bucaram, and A. Schmitz. "Price Relationships in the U.S. Sweetener Market: A Cointegration Approach." *International Sugar Journal* 110,1314(2008):358–63.

Gardiner, W.H., R.O. Roningen, and K. Liu. "Elasticities in the Trade Liberalization Database." Staff Report No. AGEC 89-20. Washington, D.C.: Agriculture and Trade Analysis Division, Economic Research Service, United States Department of Agriculture, 1989.

Katz, M., J.F. Bruneau, and A. Schmitz. "Identifying and Applying a Comparative Advantage Framework in Canadian Supply-Managed Agriculture." *Canadian Journal of Agricultural Economics* 56,2(2008):129–44.

Lopez, R.A. "Economic Surpluses in the U.S. Sugar Market." *Northeastern Journal of Agricultural and Resource Economics* 19,1(1990):28–36.

———. "Political Economy of U.S. Sugar Policies." *American Journal of Agricultural Economics* 71,1(1989):20–31.

Moss, C.B., and A. Schmitz. "Coalition Structures and U.S. Sugar Policy." *Sugar and Related Sweetener Markets: International Perspectives*. A. Schmitz, T.H. Spreen, W.A. Messina, and C.B. Moss, eds., pp. 259–80. Wallingford, UK: CABI Publishing, 2002.

Petrolia, D.R., and P.L. Kennedy. "Increasing the United States Tariff-Rate Sugar Quota for Cuba and Mexico: A Partial-Equilibrium Simulation." *Journal of Agricultural and Applied Economics* 35,3(2003):589–97.

Rude, J., and J.-P. Gervais. "Tariff Rate Quota Liberalization: The Case of World Price Uncertainty and Supply Management." *Canadian Journal of Agricultural Economics* 54,1(2006): 33–54.

Schmitz, A. "Supply Management in Canadian Agriculture." *Canadian Journal of Agricultural Economics* 31,2(1983):135–52.

———. "Canadian Agricultural Programs and Policy in Transition." *Canadian Journal of Agricultural Economics* 56,4(2008):371–92.

Schmitz, A., G. Coffin, and K. Rosaasen, eds. *Regulation and Protectionism under GATT: Case Studies in North American Agriculture*. Boulder, CO: Westview Press, 1996.

Schmitz, T.G., A. Schmitz, and J.L. Seale, Jr. "Brazil's Ethanol Program: The Case of Hidden Sugar Subsidies." *International Sugar Journal* 105,1254(2003):254–65.

Tyers, R., and K. Anderson. *Disarray in World Food Markets: A Quantitative Assessment*. Hong Kong: Cambridge University Press, 1992.

Vercammen, J.A., and A. Schmitz. "Supply Management and Import Concession." *The Canadian Journal of Economics. Revue Canadienne d'Economique* 25,4(1992):957–71.

United States Department of Agriculture. *Sugar and Sweetener Situation and Outlook. USDA/ERS SSS-250*. Washington, D.C.: Economic Research Service, United States Department of Agriculture, 2007.

Uri, N.D., and R. Boyd. "Assessing the Impact of the Sugar Programme on the U.S. Economy." *Food Policy* 19,5(1999):443–57.

Appendix

Calculation of Slopes and Intercepts

At the initial domestic price of U.S. $505.39 per mt (22.92 cents per pound.), 9,079 thousand mt of sugar is demanded in the U.S. market (Figure A1). This is comprised of 7,597 thousand mt produced domestically and 1,482 thousand mt imported.

In the case of a demand elasticity of −0.6, the slope of the demand curve (change in price over change in quantity) is determined as follows:

Demand Slope = 1 / (Demand Elasticity * Quantity Demanded / Price)

or 1 / (−0.6 * 9,079 / 505.39) = −0.09278.

The price axis intercept for total demand is determined by:

*Total Demand Intercept = Price – Demand Slope * Total Quantity Demanded*

or 505.39 – (−0.09278 * 9,079) = 1347.71.

The price axis intercept for domestic demand (total demand less imports) is determined by:

*Domestic Demand Intercept = Price – Demand Slope * Domestic Quantity Demanded*

or 505.39 – (−0.09278 * 7,597) = 1210.21.

In the case of a supply elasticity of 0.5, the slope of the supply curve (change in price over change in quantity) is determined as follows:

*Supply Slope = 1 / (Supply Elasticity * Quantity Supplied / Price)*

or 1 / (0.5 * 7,597 / 505.39) = 0.13305.

The price axis intercept for domestic supply is determined by:

*Supply Intercept = Price – Supply Slope * Domestic Quantity Supplied*

or 505.39 – (0.13305 * 7,597) = −505.39.

Supply slopes, demand slopes, and their respective intercepts for demand elasticities of −0.1. −0.3, and −0.6, and a supply elasticity of 0.5 are shown in Table A1.

Calculation of Producer and Consumer Surplus

The producer surplus is the positive area above the supply curve and below the domestic price, as represented by area *D* in Figure A1. In this case, involving a truncated supply curve, the producer surplus does not include any of the area below the zero price line. Producer surplus is determined by the equation:

*Producer Surplus = Domestic Quantity Supplied * (Price – Supply Intercept) / 2 – ((Supply Intercept / Supply Slope) * Supply Intercept) / 2*

or 7,597 * (505.39 – (−505.39)) / 2 − ((−505.39 / 0.13305) * (−505.39)) / 2 = 2,879,586.

In a similar fashion, the consumer surplus is determined by the equation:

*Consumer Surplus = ((Domestic Quantity Demanded + Import Quota) * (Total Demand Intercept − Price)) / 2*

or ((7,597 + 1,482) * (1347.71 − 505.39)) / 2 = 3,823,697.

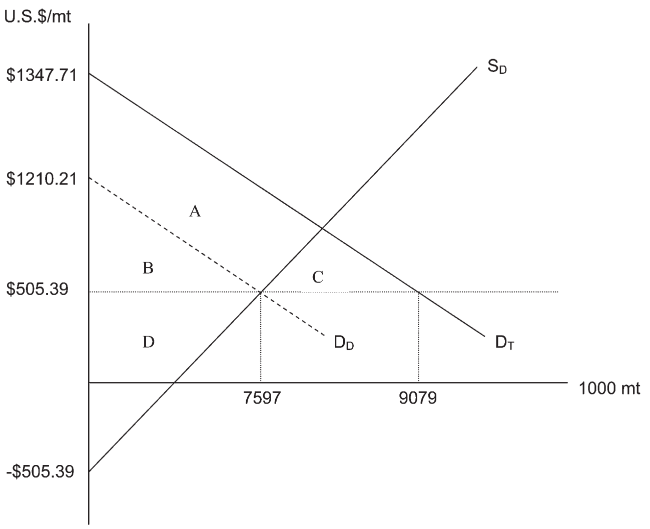

Figure A1. Example of Supply and Demand Slopes and Intercepts and Producer and Consumer Surplus with a Supply Elasticity of 0.5 and a Demand Elasticity of −0.6

Table A1. Slopes and Intercepts Associated with U.S. Sugar Supply Elasticity and Alternative Demand Elasticities

Demand Elasticities	Slope	Domestic Demand Price Intercept (U.S.$/mt)	Total Demand Price Intercept (U.S.$/mt)
−0.1	−0.55666	4734.32	5559.29
−0.3	−0.18555	1915.03	2190.02
−0.6	−0.09278	1210.21	1347.71
Supply Elasticity	Slope	Supply Price Intercept	
0.5	0.13305	−505.39	