The Effect of the Sugar Program on the U.S. Economy: A General Equilibrium Analysis

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Abstract: *This study examines the effect of the sugar tariff-rate import quota program on the U.S. economy. Based on a computable general equilibrium model, the analysis suggests that a complete elimination of the sugar program will reduce output for all producing sectors by about $2.85 billion. For producing sectors in addition to the agriculture-program crops, crude oil and petroleum refining sectors, output will increase by about $2.98 billion. Additionally, there will be an increase of about $197 million and $121 million in the consumption of goods and services and in welfare, respectively. The government sector realizes a reduction in revenue of about $15 million.*

Key Words and Phrases: *General equilibrium model, Consumer welfare, Sugar program, Tariff-rate quota.*

The United States has had some type of sugar program since 1789 (Schmitz, Allen and Leu). The sugar program was originally intended to raise revenue, but later evolved into a scheme mainly to protect domestic sugar cane and sugar beet producers from foreign competition. In recent times, the program has taken the form of a support price with domestic market quota allocations administered by the U.S. Department of Agriculture (USDA). In addition, country-by-country quotas are imposed which result in the domestic price of sugar being above support levels, thereby avoiding any direct cost to the U.S. government.[1]

The current U.S. sugar program has had a number of effects. One is that it has created a complicated picture of the caloric sweetener market in the United States. Besides sucrose (i.e., sugar), the caloric sweetener market consists of glucose, dextrose and high fructose corn syrup (HFCS). The dominant caloric substitute for sugar is HFCS.[2] Consumption of HFCS has increased dramatically since its introduction in the late 1960s. It has displaced sugar almost entirely in soft drinks based on price considerations alone (Uri, 1993). HFCS has also displaced sugar in other uses, although this has been more limited due to technical considerations. Because HFCS is substitutable for sugar in many uses (Moore and Buzzanell; Morris;

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Nordlund; Page and Friend), the sugar program directly affects the HFCS market and the corn market from which the HFCS feedstock is obtained.[3]

Another important effect of the sugar program is that it has created a substantial disparity between the domestic and world price of sugar (Figure 1).[4] With such a divergence, there are winners and losers as a result of the program. Thus, the objectives of this study are to develop a computable general equilibrium model, which depicts the interrelationships between the sugar program and the U.S. economy, and to quantify and analyze the effects of the sugar program in terms of who gains, who loses and by how much. In what follows, an overview of the U.S. sugar program and the modeling approach is presented, followed by a brief discussion of the data used in the empirical analysis. Next, the results of the general equilibrium model, with and without the sugar program, are discussed. Finally, the study draws some policy implications with reference to elimination of the program.

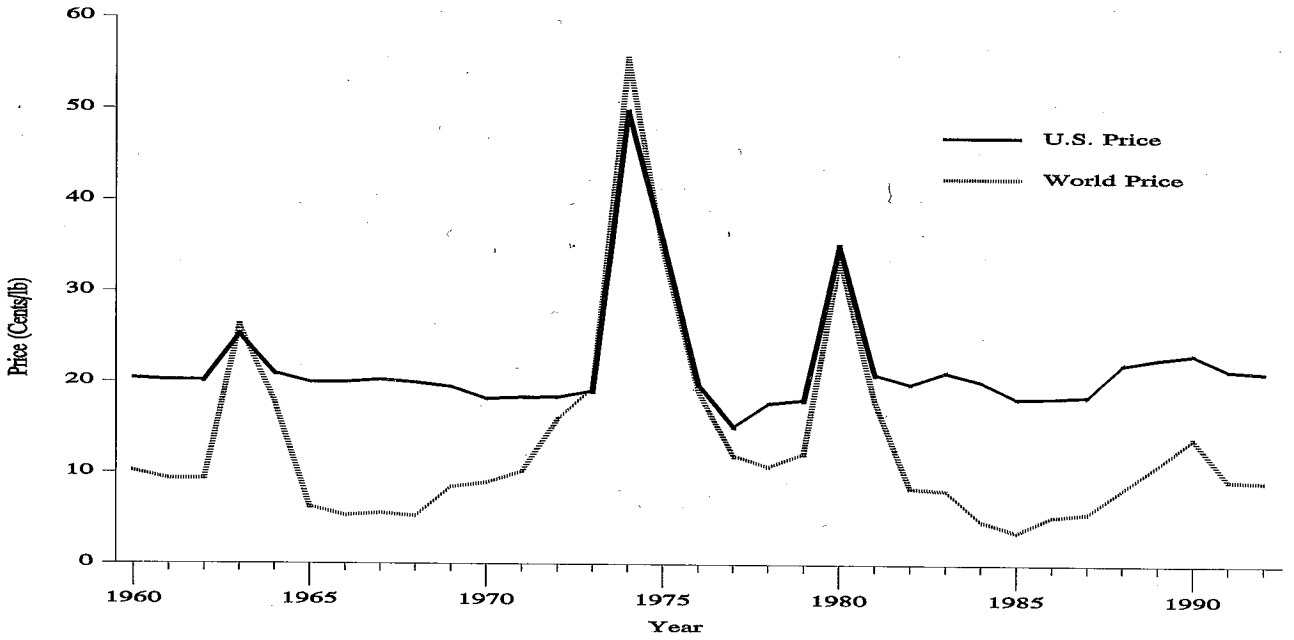
The Sugar Program

The outline of the current sugar program, as configured in the Food, Agriculture, Conservation, and Trade Act of 1990 (P.L. 101-624), was set in place in the Food and Agriculture Act of 1981 (P.L. 97-98). Designed to operate at no net cost to the federal government, the sugar program provides three tools to support domestic sugar prices which are administered by the USDA: 1) a nonrecourse loan, 2) a tariff-rate import quota and 3) standby domestic marketing allotments.

The loan program guarantees sugar producers a minimum support price for their sugar. The loan program, however, must operate without cost to the federal government. Raw cane and refined beet sugar are used as the collateral for loans obtained. The processors use the loans to pay growers for their cane and beets upon delivery to the processing facility. Growers typically receive at least 60 percent of the loan at delivery. Final payment is made to the grower based on the price at which the sugar was sold. When the sugar is sold, the processor repays the loan.

The loan program effectively sets the guaranteed price because producers can forfeit, without penalty, their sugar which serves as collateral for full payment of the loan. Processors may choose to forfeit their sugar rather than repay the loan if the market price for sugar is not sufficient to recover the additional costs involved in selling the sugar. The program's provision of no net cost to the federal government has brought about the use of an import quota to keep sugar prices sufficiently high to prevent forfeitures.

Figure 1.
Real Domestic and World Price of Raw Sugar, 1960-1992



Note: The domestic raw sugar prices are c.i.f. duty-free paid. The world prices are f.o.b. Caribbean, contract number 11. Both price series are in real terms. The gross domestic product implicit price deflator is used in computing the real series.

Source: Barry *et al.* and Economic Research Service (December 1992).

Currently, a tariff-rate import quota is used to restrict the supply of foreign raw cane sugar and, hence, to support the domestic price of sugar. A tariff-rate import quota permits only a limited quantity of sugar to be imported at a low tariff level. Any imports above this level are assessed a relatively high second-tier tariff. Under this system foreign producers may exceed their quota, but any sugar exported to the United States in excess of their quota is assessed a $0.16 per pound tariff. This tariff is high enough to effectively preclude additional sugar exports to the United States.

The USDA annually estimates the domestic production, quantity demanded and supply needed to keep domestic prices at a level that prevents producers from forfeiting sugar. In consultation with the Sugar Working Group, the USDA then determines the quantity of sugar to import. The Sugar Working Group is composed of representatives of various government agencies with an interest in the sugar program. The Food, Agriculture, Conservation, and Trade Act of 1990 requires that the quota be at least 1.25 million short tons to ensure that sugar cane refiners continue to have access to foreign raw sugar. The quota also enables the federal government to meet foreign policy objectives. The U.S. Trade Representative allocates the quota to individual countries that export sugar to the United States.

If the import quota is met and the price of sugar falls below the forfeiture level, domestic marketing allotments will be used to support prices. These allotments limit the quantity of domestically produced sugar and crystallized HFCS each manufacturer can sell. Marketing allotments are administered according to marketing rights based on historical production, ability to market sugar, and production capacity of sugar cane millers and sugar beet processors. On June 30, 1993, for the first time, the USDA announced market allotments for sugar and crystalline fructose for fiscal year 1993 (U.S. Department of Agriculture, Sept. 1993).

The Modeling Approach

The sugar sector is closely interrelated to other sectors of the economy because sugar is not only an input into many production processes, but also consumed directly by consumers (Uri, 1993). In 1991, approximately 55 percent of the U.S. sugar supply was used in the manufacture of ice cream and dairy products; canned, bottled and frozen foods; and bakery, cereal, and allied products. Additionally, sugar used in the production of beverages, including soft drinks and noncarbonated beverages, accounted for another 2.5 percent. Finally, about 40 percent of the sugar was sold to consumers through retail and wholesale grocery outlets.

A comprehensive analysis of the sugar program is employed to account for the linkages between economic sectors and the responsiveness of producers and consumers both to absolute and relative changes in the prices of the various goods and services (including sugar). In this study, the incidence of the sugar program is endogenous to the analysis with no prior assumptions being made. The analytical approach used is a computable general equilibrium model that has been disaggregated into fourteen producing sectors, fourteen consuming sectors, six household categories (Table 1) and one government sector. This level of disaggregation allows for an assessment of the direct effects as well as the indirect effects of the sugar program. By measuring these effects, we identify the extent to which the agricultural sectors (e.g., sugar producers) and the other producing and consuming sectors and household groups gain or lose. Hence, equity considerations as well as efficiency considerations can be addressed.

The General Equilibrium Model. The use of a general equilibrium model to assess the effect of the sugar program on the economy is not unique to this study. An earlier application was provided by Rendelman. In his analysis, Rendelman uses a static model and considers consumers only in the aggregate. Consequently, the distributive (equity) effects of the sugar program cannot be evaluated. Another shortcoming of Rendelman's model is that no government sector is included in the analysis. The model presented below attempts to address these shortcomings.

This study follows Shoven and Whalley's tax analysis research and incorporates some methodological enhancements of the general equilibrium model developed by Hudson and Jorgenson. Specifically, the study recognizes the differences in consumer preferences as a function of their incomes and specifies a distinct demand system for each group of households. In addition, a neoclassical microeconomic model of producer behavior that contains a price-responsive input-output component is employed. The consumer behavior model is integrated with the producer behavior model to provide a comprehensive framework for policy simulations.

The producing sectors. The production sector of the model consists of an input-output matrix with flexibility for substituting factor inputs (capital, labor and land). Technologies are represented by production functions that exhibit constant elasticities of substitution (CES). Absence of technological progress, both embodied and disembodied (e.g., Uri, 1984), is assumed over the period of investigation. Furthermore, for each production sector the value added by the specific sector is assumed as a function of labor and capital.[6]

Table 1.
Classification of Producing Sectors, Consuming Sectors, and Household Income Categories, 1988

Industries (Producing Sector)	
1. Manufacturing	8. Financial
2. Coal Mining	9. Forestry
3. Other Mining	10. Wood Products
4. Service	11. Crude Oil & Natural Gas
5. Chemicals & Plastics	12. Agriculture 1 - Program Crops
6. Food & Tobacco Products	13. Agriculture 2 - Livestock
7. Petroleum Refining	14. Agriculture 3 - All Other Agri.
Goods and Services (Consuming Sector)	
1. Food	8. Financial Services
2. Alcohol & Tobacco	9. Other Services
3. Utilities	10. Motor Vehicles
4. Furnishings & Appliances	11. Gasoline & Other Fuels
5. Housing	12. Reading & Recreation
6. Clothing & Jewelry	13. Nondurable Household Items
7. Transportation	14. Savings
Household Income Categories	
I. Less than $10,000	IV. $30,000 - $39,999
II. $10,000 - 19,999	V. $40,000 - $49,999
III. $20,000 - 29,999	VI. $50,000 and over

For the three agricultural sectors and the forestry sector, a third factor of production—land—is included because it is an especially important input to these sectors. Note that sugar production is included in the Agriculture 1—Program Crops sector. The incorporation of land into the production function is accomplished by nesting the CES production function. In particular, an input is defined solely as a function (in CES form) of land and

capital which, in turn, takes the place of capital in the original production function specification.[7]

The consuming sectors. On the demand side, the model captures the behavior of consumers, the government and foreigners. Consumers are grouped according to income (Table 1) and a demand system is specified for each group. Each income group has an endowment of labor and capital. Given the vector of prices, consumers decide the amount of each good and service to consume (purchase) and the amount to save and invest. Thus, the consumers also serve as investors in the model and their investments are determined by the amount of their savings.

The output of the fourteen producing sectors accrues to the owners of the factors of production which they sell. With the receipts from sales, these individuals either consume domestic or foreign goods and services, save, or pay taxes to the government. The savings are used for investment and the taxes are ultimately returned to these individuals in the form of government assistance and services provided.

The demand for final goods and services comes from three primary sources: 1) final goods and services directly consumed by individuals, 2) investment (which is equal to savings) and 3) foreign demand. Note that the composition of the consumer goods and services sectors in Table 1 does not match that of the producing sectors. This is because the final goods and services produced by the producing sectors must go through various channels (i.e., transportation and distribution) before they are consumed. To address this problem, a transformation matrix is introduced that defines the contribution of each producing sector to the composition of each of the final (consumer) goods and services.

For each category of households (Table 1), utility is assumed to be a weighted CES function of the fourteen consumer goods and services. The weights on these goods and services, which are household-category specific, are computed as the share of total purchases going to a specific consumer good or service. The nature of the CES utility function implies that the elasticity of substitution is the same between any pair of goods and/or services. Due to lack of reliable estimates, the respective substitution elasticities across pairs of goods and/or services are assumed to equal one for all of the combinations. Finally, consumers obtain utility from the consumption of all goods and services including leisure (consumer good and service sector number 12). Hence, it is necessary to determine a weight for this factor in the utility function. For the purpose of this analysis, the value of leisure is assumed to be 0.5 times labor income. The net effect of adding leisure is to account explicitly for the fact that consumers not only derive utility from the act of consuming goods and services, which comes from

owning the factors of production, but also from leisure. Thus, an increase in leisure can lead to an enhancement of individual well-being in the model.

A household's budget constraint is defined such that expenditures on goods and services must be less than or equal to its income. Household income is defined as the sum of returns to its endowment of factors of production including labor, capital and land. That is, household expenditures must be less than or equal to the total factor payments received. Maximizing utility subject to this expenditure constraint yields the demand functions for the various goods and services by household categories (Mixon and Uri). Since savings are considered one of the items in an individual's utility function, the choice between consumption and savings, i.e., intertemporal tradeoffs, is made explicit as an integral part of the model.

The second component of the demand for goods and services is investment. Total investment is disaggregated (through a transformation matrix) by the sector of the economy that produces it. For the purposes of constructing and calibrating the general equilibrium model, investment is taken directly from the national income and product accounts as compiled by the Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce and reported in the *Survey of Current Business*. Given the assumption that savings and investment are exactly equal, personal savings are scaled to equal the gross investment observed for each of the fourteen producing sectors.

The last component of demand for goods and services is the demand by foreign consumers. The foreign sector produces imports and consumes exports. In other words, foreigners are regarded as consumers who purchase U.S. exports with income produced from the sale of imports to the United States. The model assumes a balanced trade in an open economy (i.e., the nominal values of exports and imports are assumed equal in equilibrium). The exchange rate, however, is not explicitly incorporated into the model specification.

In the model, exports are delineated by producing sectors with a transformation matrix analogous to that used for the consumption of final goods and services. A similar delineation is utilized for imports. The exports and imports are then scaled so the total foreign account is balanced. Finally, the import and export demand relationships for each producing sector are constructed by employing the demand and supply elasticities estimated by Boyd.

The government sector. The government levies taxes on factors of production, output, income and consumption. Revenues are distributed back to consumers as income for purchasing goods and services, capital and labor. The government is treated as a separate sector with a CES produc-

tion function in the general equilibrium model. The elasticity of substitution is assumed to be one. This means the CES production function collapses to a Cobb-Douglas type production function.

Taxes are collected in various forms. The model includes explicitly personal income tax, labor taxes (e.g., a social security tax), capital taxes (e.g., a corporate income tax), property taxes, and sales and excises taxes. All these are treated as *ad valorem* taxes and a marginal rate is used for each household category, consumer good and service sector, producing sector and factor output. In this respect, the model is a distinct improvement over earlier general equilibrium models (e.g., Shoven and Whalley) which simply employed lump sum transfer schemes or used average tax rates.

A Mathematical Statement of the Model. For a general equilibrium to exist given the foregoing considerations, it is useful to state precisely the conditions for which the model must satisfy. First, there cannot be positive excess quantities demanded. That is,

$$\sum_{j=1}^{m} a_{ij} M_j - E_i (\boldsymbol{p}, \boldsymbol{Y}) \geq 0, \quad \text{for } p_i \geq 0 \tag{1}$$

where i ($i = 1,2 \ldots, n$) denotes the consumer goods and services; M_j ($j = 1,2 \ldots, m$) denotes the activity levels; a_{ij} denotes the ij element in the activity analysis matrix; $\boldsymbol{Y}$ denotes a vector of incomes for the k consumers; $\boldsymbol{p}$ denotes a vector of prices for the n consumer goods and services; and E_i denotes the excess demand for good or service i.

The second requirement for general equilibrium is that the economic profits associated with a given activity are non-positive (i.e., there are no monopoly rents). That is,

$$-\sum_{i=1}^{n} a_{ij} p_i \geq 0, \quad \text{for } M_j \geq 0. \tag{2}$$

Finally, all prices and activity levels must be non-negative. That is,

$$p_i \geq 0, \quad \text{and} \quad M_j \geq 0. \tag{3}$$

The model is solved for a general equilibrium using the iterative algorithm nominally referred to as the Sequence of Linear Complementary Problems (SLCP) developed by Mathiesen.[8] This algorithm is based on the fixed point theorem proved by Scarf.

The Data

To analyze the potential impacts of a complete elimination of the sugar program on the U.S. economy, the general equilibrium model discussed above was estimated using the 1988 data. For each of the fourteen producing sectors, data on capital receipts and taxes were computed from reports of the BEA, the USDA, the U.S. Department of Energy and from Hertel and Tsigas. The various elasticities of substitution employed in the analysis were obtained from Boyd.

Capital earnings and labor income were obtained from the BEA. Land income was estimated using factor shares obtained from the Economic Research Service (ERS) of the USDA and applied to the capital earnings component noted above. Expenditure data for each of the fourteen goods and services by household categories were obtained from the *Consumer Expenditure Survey: Interview Survey, 1984* (U.S. Department of Labor). By combining this information with the number of households in each income category obtained from the BEA, the aggregate expenditures on each category of consumer goods and services by household category were computed. The various tax rates used in the analysis were obtained from a variety of sources including the Internal Revenue Service, the ERS, Hertel and Tsigas, and Ballard *et al.* These rates, as noted previously, are marginal. The values of exports and imports in 1988 were taken from various issues of the *Survey of Current Business* with the exception of the energy and agriculture data. The energy and agriculture data were obtained from the Energy Information Administration of the U.S. Department of Energy and the ERS, respectively.

The price responsiveness of the demand for sugar is an important consideration. For the purpose of this study, this price responsiveness, measured as an own price elasticity, is assumed equal to -0.50 (Uri, 1993). This means that for each one percent reduction in the price of sugar, the quantity demanded will increase by 0.50 percent. The assumption of the own price elasticity has important implications for the results of the analysis. Because the own price elasticity of -0.50 is somewhat larger than that used in other studies, a sensitivity analysis is performed in which the elasticity measure is allowed to vary around the point estimate.

Results and Discussion

The general equilibrium model was first estimated to provide the baseline estimates with the sugar program in effect. The model was then re-estimated assuming that the sugar tariff-rate import quota was completely eliminated. Thus, by comparing these results with the reference case, the

effects of program elimination can be ascertained and analyzed easily. Note that additional assumptions were made in the estimation of the no-sugar-program general equilibrium model. Specifically, a positive sugar import elasticity and a positive change in world sugar price were assumed. It is expected that the United States demand for sugar will increase with the elimination of the sugar program. Since the United States is such a large sugar importer, this increase in demand will have a positive impact on the world sugar market to cause an upward price adjustment. Therefore, instead of assuming that the U.S. sugar price will fall to the world level, the presumption is the world sugar price will increase with the elimination of the sugar program. In what follows, the results of the complete elimination of the program on the U.S. economy with respect to the producing sector, the consuming sector, the household categories and the government sector are discussed.

Effects of Removing Sugar Tariff-Rate Import Quota. The impacts of the complete elimination of the sugar program on the producing sector are presented in Table 2.[9] To provide a basis for comparison, the equilibrium prices and quantities with the program in effect are shown for the reference case. The total output of the producing sectors is valued at about $8,100 billions in 1988. Note that the magnitude of the equilibrium values *per se* is of little importance. The significance of these measures is to reflect the relative changes corresponding to the policy initiative that perturbs the general equilibrium.

As shown in Table 2, in response to the elimination of the sugar program, total output in the producing sectors will fall by 0.035 percent or by about $2.85 billion. This decrease, however, is somewhat misleading since it is not spread uniformly across producing sectors. For example, the output of the agricultural program crops sector, which includes both sugar and corn production, will fall by 2.41 percent ($1.76 billion).[10] The domestic price of sugar would fall both in relative and absolute terms. This results from the increased availability of sugar at a lower price. With the lower price and greater availability of sugar in the world market, less sugar will be produced domestically and more will be imported. With the fall in the relative price of sugar, less HFCS will be demanded as sugar is substituted for HFCS, resulting in a reduction of corn prices.

The two other sectors adversely affected in terms of reduced output are the crude oil producing sector and petroleum refining sector. The fall in the output in these sectors is an artifact of the model assumptions.[11] In particular, exports and imports are scaled so the total foreign account is balanced. With the change in the price of sugar relative to the price of crude oil (sugar is relatively cheaper after the sugar tariff-rate import quota

Table 2.
Equilibrium Prices (normalized) and Quantities (in hundreds of billions of dollars) for the Producing Sectors, 1988

Sector	Reference Case		No Sugar Program		Percent Change[a]
	Price	Quantity	Price	Quantity	
1. Manufacturing	1.00000	22.39770	1.00000	22.40190	0.018
2. Coal Mining	1.00000	0.28022	0.99994	0.28089	0.239
3. Other Mining	1.00000	0.23889	0.99979	0.23892	0.013
4. Service	1.00000	34.07910	1.00001	34.09240	0.039
5. Chemicals and Plastics	1.00000	3.37973	0.99996	3.38121	0.044
6. Food and Tobacco Products	1.00000	3.85858	0.99858	3.86282	0.110
7. Petroleum Refining	1.00000	1.64365	0.99877	1.64338	-0.164
8. Financial	1.00000	8.60248	1.00002	8.60251	0.001
9. Forestry	1.00000	0.15030	0.99547	0.15089	0.393
10. Wood Products	1.00000	2.28792	0.99983	2.28951	0.069
11. Crude Oil and Natural Gas	1.00000	1.29060	0.99771	1.25005	-3.142
12. Agriculture 1 - Program Crops	1.00000	0.72849	0.99682	0.71094	-2.409
13. Agriculture 2 - Livestock	1.00000	1.41446	0.99599	1.41752	0.216
14. Agriculture 3 - All Other Agriculture	1.00000	0.69644	0.99626	0.69707	0.090
Total	1.00000	81.04856	0.99973	81.02002	-0.035

[a]The percent change represents the percentage change in the equilibrium quantities between the elimination of the sugar program and the reference case.

is eliminated as shown in Table 2), more of the available foreign exchange will be devoted to imports of sugar and less to crude oil. This results in less crude oil being imported, produced and refined.

Except for the agriculture-program crops, crude oil and petroleum refining sectors, elimination of the sugar program will actually increase output in the other producing sectors by 0.038 percent ($2.98 billion). The magnitude of sector specific effects, however, are somewhat variable. For example, output for the service sector, will increase by 0.039 percent ($1.33 billion). In response to lower sugar prices, output in the manufacturing sector will increase by 0.018 percent ($420 million) while output in the food and tobacco products sector will expand by 0.110 percent ($424 million). Output in the coal mining sector increases by 0.239 percent ($67 million) as coal is substituted for the crude oil in the generation of electricity. Furthermore, output in the livestock and all other agriculture sectors will increase by 0.216 percent ($306 million) and 0.090 percent ($63 million), respectively. These effects are caused by shifting some of the land from production of sugar and corn to production of livestock and other agricultural commodities.

Accompanying the changes in agricultural output are changes in the prices of the agricultural commodities. The results suggest that the price of the program crops will fall by 0.318 percent due to sugar being imported at the world price. Moreover, the prices of livestock and all other agricultural commodities will be reduced by 0.401 percent and 0.374 percent, respectively. These latter price decreases are the result of increasing production of livestock and other agricultural commodities in response to the lower sugar and corn prices.

Finally, imports of sugar, livestock and all other agricultural commodities will expand by 4.701 percent ($230 million), 0.178 percent ($936 thousand) and 0.769 percent ($839 thousand), respectively. These increases in imports are caused by the reduction in the domestic prices of these agricultural commodities in the absence of the sugar program.

With regard to the consuming sectors, the elimination of the sugar program results in an increase in the consumption of goods and services by about 0.005 percent or $197 million (Table 3). The food sector benefitted the most with a 0.063 percent ($344) million increase in consumption. The second most significantly affected sector (in percentage terms) is the alcohol and tobacco sector, which realizes a 0.061 percent ($67 million) rise in consumption. Most other sectors experience minimal changes attributable to the indirect effects of the sugar program elimination. These indirect effects include a slightly higher real income brought about by a reduction in the price of sugar and corn. In addition, changing relative prices also leads

Table 3.
Equilibrium Prices (normalized) and Quantities (in hundreds of billions of dollars) for the Consuming Sectors, 1988

Sector	Reference Case		No Sugar Program		Percent Change[a]
	Price	Quantity	Price	Quantity	
1. Food	1.00000	5.49502	0.99929	5.49846	0.063
2. Alcohol and Tobacco	1.00000	1.10121	0.99930	1.10188	0.061
3. Utilities	1.00000	1.97800	1.00036	1.97709	-0.046
4. Furnishings and Appliances	1.00000	1.26292	0.99999	1.26285	-0.006
5. Housing	1.00000	5.52584	1.00001	5.52534	-0.009
6. Clothing and Jewelry	1.00000	2.64025	0.99999	2.64008	-0.006
7. Transportation	1.00000	0.39273	1.00001	0.39271	-0.005
8. Financial Services	1.00000	1.78548	1.00002	1.78529	-0.010
9. Other Services	1.00000	7.64461	1.00001	7.64409	-0.007
10. Motor Vehicles	1.00000	3.03739	1.00000	3.03716	-0.008
11. Gasoline and Other Fuels	1.00000	0.85038	0.99938	0.85083	0.053
12. Reading and Recreation	1.00000	2.69636	0.99988	2.69648	0.004
13. Nondurable Household Items	1.00000	1.21342	0.99992	1.21342	0.000
14. Savings	1.00000	2.66049	0.99999	2.66039	-0.004
Total	1.00000	38.28410	0.99987	38.28607	0.005

[a]The percent change represents the percentage change in the equilibrium quantities between the elimination of the sugar program and the reference case.

to substitution of relatively less expensive for relatively more expensive goods and services.

Table 4 shows that aggregate utility is expected to increase by 0.001 percent ($121 million) for all household categories when the sugar program is abolished.[12] The increase, however, is not distributed evenly across households. Category I and Category II households suffer a decline in utility while the utility level of the remaining households increases. The reduction in utility of the Category I and Category II households is the result of relatively higher prices for utilities, housing and transportation. These commodities are consumed in greater proportion by these category households relative to the remaining household categories.[13] Thus, considering all direct and indirect effects of abolishing sugar import quotas, the policy option is, in general, regressive. That is, the adverse effects of eliminating the sugar program fall mostly on the lowest household income categories. The effects, however, are extremely small and cannot be estimated precisely by the model.

Table 4.
Equilibrium Utility Levels (in hundreds of billions of dollars) by Household Categories, 1988

Category	Utility Level		Percent Change[a]
	Reference Case	No Sugar Program	
I[b]	2.46325	2.46292	-0.001
II	5.03590	5.03535	-0.001
III	7.73044	7.73051	0.001
IV	8.03518	8.03546	0.001
V	6.36474	6.36518	0.001
VI	16.71870	16.72000	0.001
Total	46.34821	46.34942	0.001
Government	7.71151	7.71136	-0.001

[a]The percent change represents the percentage change in the equilibrium quantities between the elimination of the sugar program and the reference case.
[b]Note that the household categories correspond to those defined in Table 1.

The government realizes a slight reduction in revenue by abolishing the sugar program (Table 4). This result is primarily due to changes in theconsumption patterns of goods and services that have low tax rates. The aggregate effect in the reduction of government revenue is estimated to equal 0.001 percent or about $15 million.

A Comparison. Most of the existing studies on the effects of the sugar program are partial equilibrium in nature. Tarr and Morkre estimate sugar producers benefit $414 million from the tariff-rate import quota while consumers lost $735 million. Dardis and Young estimate benefits to sugar producers at between $782 and $886 million and the losses to consumers at between $1.9 to $2.4 billion. Leu, Schmitz and Knutson, focusing on the interactions between the sugar and corn and corn syrup markets, approximate producer gains to be $169 million to $578 million and consumer losses to be $372 million to $1.6 billion. Using a simple single equation partial equilibrium model, Maskus suggests that producer benefits are about $700 to $840 million. Sturgis, Field and Young, using an amorphous simulation model, estimate that producer gains are in the neighborhood of $800 million and consumer costs are approximately $1.0 billion. The U.S. General Accounting Office, using a partial equilibrium model, estimates consumer costs to be $1.4 billion annually with the majority of program benefits accruing to a few sugar and HFCS producers. Using a partial equilibrium model that looks at the entire agricultural sector, Tanyeri-Abur *et al.* estimate that consumer welfare gains would be approximately $800 million with the elimination of the sugar program. Finally, Rendelman estimates that consumer costs are approximately $1.59 billion based on a general equilibrium model.

If producer benefits in this study are measured solely by the increased output of sugar and corn, then producer benefits are approximately $1.76 billion. This is somewhat larger than the estimate of most other studies. It captures not only the direct effects of the higher sugar prices, but also the indirect effects associated with the higher relative price of sugar and the effects on the price of corn used in manufacturing HFCS. As for consumer costs, this study estimates consumer losses due to sugar programs at about $197 million in terms of reduced consumption of goods and services. This estimate is lower than that obtained by most other studies. As in the case of producerbenefits, this value reflects not only the direct costs of the higher absolute prices of sugar and corn, but also the indirect effects of relative price distortions.

Sensitivity Analysis. Simulations were conducted by changing the reference price elasticity of sugar demand from -0.5 to -0.25 and -0.75. In general, the effect of raising the absolute value of the own price elasticity

is to magnify the influence of the sugar program. The effect, however, is minimal. Under the different assumptions concerning the own price elasticity of demand for sugar, neither output nor consumption is affected by more than $125 million and in no case is there any change in the qualitative results discussed above.

These sensitivity results suggest that the magnitude of own price elasticity of demand for sugar is not so pivotal to the model. While the elasticity is important in the determination of the equilibrium prices and quantities and the policy implications, the model appears reasonably robust with regard to the assumption of own price elasticity of demand for sugar. That is, an error in the estimated price elasticity does not necessarily lead to misleading and nonsensical results.

Conclusion

The foregoing analysis has examined the effect of the sugar tariff-rate import quota program on the U.S. economy. The analytical approach used a computable general equilibrium model which is composed of fourteen producing sectors, fourteen consuming sectors, six household categories classified by income, and one government sector. The effects of abolishing the tariff-rate import quota sugar program on prices and quantities are examined.

Results suggest that a complete elimination of the sugar program will lower the total output of all producing sectors by about $2.85 billion. However, for producing sectors besides agriculture—program crops, crude oil, and petroleum refining sectors—output will actually increase by about $2.98 billion. For the agricultural sectors, output in the program crops sector will fall by about $1.76 billion and outputs in the livestock and all other agriculture commodities sectors will increase by $306 million and $63 million, respectively. The consumption of goods and services will increase by about $197 million and consumers' welfare will increase by about $121 million. The government also will realize a reduction in revenue of about $15 million.

The results from this study differ somewhat from most other studies of the sugar tariff-rate import quota program. One possible explanation is that these other studies are typically partial equilibrium in nature. Consequently, the indirect effects of the sugar program on the other producing sectors—including the other agricultural sectors—of the U.S. economy are not captured in the partial equilibrium analysis.

As a consequence of this analysis, the implications of the sugar tariff-rate import quota have been demonstrated clearly. While some producing

sectors benefit, most are adversely affected in terms of reduced output by the program. The various consuming sectors would experience a total increase in the consumption of goods and services if the program were abolished. These changes, however, are relatively modest.

Finally, the tariff-rate import quota has been the main element of U.S. sugar policy in recent years. Without quotas, domestic sugar producers and sugar exporters to the United States would receive only the world market price. A straight tariff policy would be preferred to a quota because the quota rents determined by the excess of the sugar import price over the world price would be transformed to revenues received by the U.S. government while at the same time protecting domestic sugar cane and sugar beet producers from foreign competition.

The tariff-rate import quota, while maintaining domestic producer welfare without major government expense, as shown by the reduction in revenue associated with the elimination of the sugar program, also yields quota rents to trade partners. That is, the quotas can be interpreted as a subsidy to domestic and foreign producers. Criticism of the sugar program from domestic sugar consumers is dampened due to the relatively small impact on them as suggested in the foregoing analysis.

The tariff-rate import quota policy has kept the price of sugar high relative to the domestic price of corn. This relationship contributed to the substantial growth in the corn sweetener consumption and the related reduction in sugar demand. In response to the market changes, sugar import quotas have been cut over the years to support the domestic sugar price. Thus, sugar quotas have fallen from 2.65 million short tons in 1983 to the 1.25 million short tons specified in the Food, Agriculture, Conservation, and Trade Act of 1990. This reduction in sugar import quotas has hurt sugar exporters and has generated competition among exporters to maintain their quota levels (Leu, Schmitz and Knutson; Sturgis, Field and Young). More importantly, if the trend continues it will eventually cut into the demand for domestic sugar with the result that, rather than helping domestic producers, there will be a net reduction in income associated with the domestic sugar production.

Notes

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1. A small tariff exists for countries outside the Caribbean. These are listed in the *Harmonized Trade Schedule of the United States*, Chapter 17.

2. Fructose is, in fact, a sugar. It is an excellent substitute for centrifugal (cane and beet) sugar in many uses (Lichts; Lin and Novick). In keeping with common usage, however, HFCS will be referred to as a sugar substitute.

3. Actually, HFCS can be made from any starch and is produced in some parts of the world from tapioca, sweet sorghum and sweet potatoes. Rendelman and Hertel discuss some of the technical considerations involved.

4. A discussion of the factors giving rise to the price anomalies in 1963, 1974 and 1980 are analyzed in Bohal *et al.* and Vuilleumier. A discussion here would take the analysis too far afield.

5. Complete descriptions of the sugar tariff-rate import quota program are presented in Barry *et al.* and Lord and Barry. This section draws upon these sources.

6. There is a transformation matrix whereby raw inputs in the producing sectors are transformed into consumption goods and services. Thus, the fact that agricultural goods are combined with, say, manufacturing goods, food processing, and transportation to produce food for consumption, is accounted for. In this sequence, the substitutability between domestically produced corn and imported sugar is large but not perfect.

7. While it would be possible to simply add land as an explicit input in the production function, this would implicitly assume that the elasticity of substitution between all pairs of inputs are the same. By nesting, however, the substitution elasticities are permitted to be different between different inputs. The substitution elasticities used here are derived from the Hertel and Tsigas analysis, which discusses how substitutable land is in various uses.

8. A complete listing of the equilibrium conditions together with relevant definitions is available from the authors upon request.

9. Note that domestically produced corn and sugar are both included in the program crops sector. Sugar purchased from foreign sources is not included, however, in the program crops sector. Moreover, imported sugar is not a perfect substitute for domestically produced corn.

10. In order to limit the number of tables, some of the equilibrium prices and quantities will not be presented explicitly although selected values will be discussed. Such is the case with the prices and quantities of imported goods and services. The omitted tables are available from the authors upon request.

11. The crude oil and petroleum sectors are the only sectors so affected by the model's trade specification. Any further inaccuracies caused by such trade specifications are likely to be small owing to the relatively small size of trade in the United States.

12. Note that it is a mistake to compare producer sector "losses" with consumption and utility gains. Producing sectors' activity consists of the use of not only basic (unprocessed) inputs, but manufactured and processed inputs from the other producing sectors (through the input-output matrix) as well. Additionally, some loss by the producing sectors is a function of the depreciation of the capital stock as a result of an increase in imports. Ultimately, what is of consequence is the return to workers and this is what is reflected in the measure of consumer welfare.

13. The prices of housing, transportation and utilities rise because all three sectors rely heavily on the service and financial (non-traded good) sectors. The relative prices in these producing sectors rise after the abolition of the sugar program. Hence, even though the price of coal drops, the increases in the prices of other inputs eventually cause housing, transportation and utility prices to go up.

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