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Economic Implications of Import Barriers to Protect the U.S. Sugar Industry with Particular Reference to Hawaii

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ECONOMIC IMPLICATIONS OF IMPORT BARRIERS TO PROTECT THE U.S. SUGAR INDUSTRY WITH PARTICULAR REFERENCE TO HAWAII

Jerrold K. Leong, Frank S. Scott, Jr., and PingSun Leung

ABSTRACT

This study analyzes consumer and producer costs and benefits of a modeled price support program for sugar superimposed on the 1974–1981 period, which was essentially free of effective price support programs and characterized by extreme variations in the U.S. price of domestic sugar. The study differs from previous studies in the sense that it models a with- and without-price support scenario. The modeled price support program is based on U.S. costs of production of raw cane sugar in 1981 and is imposed with appropriate deflation on the years 1974–1980 to permit comparison with the actual scenario without price supports.

Research results indicate that an adequate price support program to maintain economic viability of the U.S. sugar industry during the 1974–1981 period would have cost consumers an additional $4.77 per capita annually for sugar. This compares to an annual average loss of $4.7 billion, or $21 per capita annually, during the research period if the U.S. sugar industry had become demised, assuming no alternative employment of production factors. The cost to the Hawaii economy would have been comparatively much more severe, amounting to $836 million annually in aggregate and $880 per capita. The program could be administered at no cost to the government through the imposition of import quotas. Per capita reduction in consumers' surplus would have averaged $1.76 annually based on the duty rate of $0.01875 per pound and $6.08 based on the 20 percent *ad valorem* rate in effect in 1981. The study is expected to provide valuable insight to policymakers for future sugar legislation.

Keywords: sugar, policy, price support programs, tariffs, quotas, consumption and production deadweight loss, producers' surplus, economic viability.

INTRODUCTION

Sugar producers in the United States have experienced some form of protection against foreign imports since 1894, when an *ad valorem* duty of 40 percent was levied on foreign imports (USDA, ERS, 1984). The Jones-Castigan Sugar Act of 1934 added quotas and other provisions, most of which were not directed at imports. Since that time, numerous provisions for protecting domestic sugar have been authorized by the U.S. Congress in special sugar acts or in more general food and agriculture acts. Among the provisions, which vary by sugar act, have been (1) price supports linked to movements of parity and wholesale indexes implemented in the form of loans or purchases, (2) tariffs, and (3) the allocation of consumption requirements among domestic and foreign suppliers through quotas.

Whereas domestic sugar support programs have been considered controversial for several decades, opposition has recently become more influential in affecting sugar policy. Primary opposition has come from consumer groups, industrial users of sugar, domestic refiners of imported sugar, and academic proponents of free trade.

During recent years, a major concern has been the cost of sugar price support programs to consumers of sugar and food products sweetened with sugar. Numerous studies have been conducted that address consumer surpluses or welfare costs in relation to benefits to producers. Most of these studies address costs and benefits to consumers and producers under various import duty scenarios, considering supply and demand response based on price elasticities. The studies are generally more concerned with the welfare effects of the increase in price resulting from a support program than in determining an appropriate support price.

This study differs from previous studies in the sense that it models a with- and without-price support scenario during a period that was essentially free of price supports for sugar. The study provides as one scenario the actual cost to consumers of sugar without a price support program during 1974–1981 and, as the other scenario, a modeled price support program based on 1981 U.S. costs of production of raw cane sugar and imposed with appropriate deflation on years 1974–1980. Annual per capita consumer surplus as a result of the support program is then compared with average annual costs to the economy if the U.S. sugar industry had become demised, with no alternative employment of factors of production, as a result of the lack of an adequate price support program.

The study hypothesizes that

(1) The annual loss in income, capital investment, and employment as a result of the demise of the U.S. sugar industry would exceed the additional cost of sugar to U.S. consumers resulting from a price support program adequate to keep the industry viable.

(2) The quantity reduction in per capita consumption of sugar would have been minimal if a price support program sufficient to keep the industry economically viable had been imposed during the 1974–1981 period.

Specific objectives of the study are

(1) To determine in retrospect the feasibility of a modeled price support program for the U.S. sugar industry during the 1974–1981 period.

(2) To investigate the probable acreage response of cane and beet sugar producers to changes in prices.

(3) To determine probable consumer welfare effects compared with per capita losses to the U.S. and Hawaii economies as a result of the demise of the U.S. sugar industry.

(4) To investigate the feasibility of tariffs and quotas as an appropriate protection policy to preserve the U.S. sugar industry.

PREVIOUS RESEARCH

Since this study is concerned specifically with costs of sugar price support programs to consumers compared with losses to the economy through the demise of an unprotected sugar industry, the literature review is limited to the determination of appropriate sugar support programs and welfare effects.

Agricultural Price Support Programs

Parity has been the basis for the computation of U.S. government price supports until recently for most agricultural commodities. The concept of parity is to preserve the purchasing power accrued to the farmer. Determination of parity is limited by the fact that changes in technology are not reflected in its computation. To better quantify such changes, costs of production have been used more recently to reflect changes in the purchasing power of agricultural producers. Sharples and Krenz (1977) have focused on the likelihood of costs of production replacing parity as a criterion for determining target prices and loan rates since the former is a better indicator of efficiency.

There is an inherent dilemma in assigning values to land and management when determining costs of production. Land evaluation is a particular problem when an upward price spiral occurs when target price and nonrecourse loan rates are premised on the cost-of-production criterion. This in turn escalates costs of production in the subsequent period. Probable solutions include (1) assisting farmers through emergencies where unusually low prices prevail, thus supplementing incomes and providing a guaranteed price, and (2) price support programs to provide some certainty about expected prices to facilitate more equitable allocations of resources.

Pasour (1980) focused on the theoretical and measurement problems inherent in attempts to base price supports on costs of production and the issue of whether reasonable, objective, and representative cost estimates can be formulated for specialized resources. Firms that employ specialized resources inhibit the determination of an average cost valuation for the industry's costs of production. He contended that although there has been some contemplation regarding either exclusion or inclusion of land cost as a factor in the cost-of-production figure, it indeed represents the producer's opportunity cost and should be included as a cost factor. Uncertainty complicates cost estimates, but is nonetheless a factor that largely determines the risk inherent in the production of a specific commodity.

Groenewegen and Clayton (1980) provided an economic rationale for farm price supports and illustrated how production costs can be used to establish them. Essentially, they challenged Pasour's reservations concerning the use of cost data as a basis for agricultural price supports. They contended that "price supports can be based on production costs, but only if the cost factors that are fixed in the short run are not directly included in the price support calculation" and that since "supports are not designed to maintain the expected opportunity cost of fixed resources," they can be eliminated from the support price formulation. Based on the above assumption, a model was formulated to adequately determine a level of price support that would be realistic and usable.

Belongia (1983) contended that the analysis presented by Groenewegen and Clayton (1980) did not distinguish between normative and positive economics and neglected to capitalize the price support program benefits accrued to producers. However, the only instance where program benefits are not capitalized is when support prices are set below a perceived equilibrium price. Belongia also asserted that producers' expectations of crop prices will affect resource values, because the expected price will be greater under a price support program.

Pasour (1983) argued that the approach presented by Groenewegen and Clayton (1980) to use price supports in this manner will neither "attract additional resources into the sector" nor "result in the capitalization of program benefits," which is not consistent with *a priori* economic theory. Pasour further contended that the importance of a specialized resource that specifically identifies increases in production cost consistent with increases in product price is absent from the Groenewegen and Clayton model. The mere fact of allowing immediate cash expenses to be met will not achieve the objective of increasing price and income if the support price is below the equilibrium price. However, the expected value of farm income will increase if the price of land and other specialized resources associated with the product increases. Thus price support programs will attract additional resources and increase cash expenses unless the proposed support level is set lower than the prevailing market price. Pasour concluded that effective price support programs ultimately redistribute incomes, and "redistribution achieved through legislative price supports can no more be justified on the basis of economic theory, than can other income transfers."

Groenewegen and Clayton (1983) extended their agricultural price support notion and addressed the three issues presented by Belongia (1983) and Pasour (1983). First, that economists play a role in establishing and in adjusting price supports and are capable of assessing the impact of price supports on consumers' and producers' welfare. Second, that the objective of a price support program is to enhance rather than stabilize income. Third, that any price support that is effective, or of any value to the producer, is capitalized into asset values. In relation to price support programs to enhance income or price, the general perception is of price supports as a vehicle not to enhance income but to stabilize income in the future. Finally, capitalization of price support program benefits as suggested by Belongia (1983) should not occur with effective price supports that are considered in conjunction with other policy instruments. In this context, a more stable price will enhance area resource allocation and better use already existing facilities to achieve a positive return on the investment of owned inputs.

Hoff (1978) presented national and regional estimates of production costs for the 1976–1977 sugarbeet crop based on a national survey questionnaire of sugerbeet producers in the United States. The USDA disaggregated questionnaires were grouped into eight beet-producing regions noting geographic boundaries and areas of absolute advantages. Both variable and fixed costs of production and processing were summarized for acreage planted. Hoff emphasized the importance of accuracy in estimating costs directly attributed to labor, farm overhead, management, irrigation, interest, and land charges.

Hoff et al. (1978) contrasted national and regional estimates of production costs for the projected 1978–1979 sugarbeet crop on a farm-weighted and production-weighted basis. The use of different yield situations facilitated the comparison of sugarbeets on a cost-per-ton basis. Projected costs of production and processing for sugarcane-producing states were also included.

Shapouri, Angelo, and Hoff (1982) presented a final updated version of production and processing costs for sugarbeets and sugarcane previously reported by Bohall, Shapouri, and Angelo (1981). Angelo and Hoff (1983) determined costs of production and processing for the 1981–1982 crop year and provided revisions for estimating a return on fixed costs.

Import Duties

Tariffs are specific or *ad valorem.* Their effects on prices and output can be determined by using a partial equilibrium analysis model. Corden (1971) provided, through linear demand and supply schedules of an importable good, an assessment of the imposition of a tariff on the total reduction in consumers' surplus. He further analyzed the effects of a tariff directly related to the following: (1) protection effect, (2) consumption effect, (3) import effect, (4) revenue effect, (5) deadweight loss-consumption, and (6) deadweight loss-production. From a partial equilibrium perspective, he assessed the impact of production subsidy and consumption tax on supply and demand schedules. The underlying assumption is that foreign supply curves are infinitely elastic, which greatly simplifies the partial equilibrium analysis. When referring to the rate of protection, defined as the "proportional increase in the price received by the domestic producers before they respond to the higher price by increasing supply," one does not refer to the protection effect, i.e., increase in production to reflect an imposition of a tariff. This supply increase depends also on the price elasticity of supply over the specific time-series. The higher the elasticity the higher the rate of protection. The analysis can be expanded to a general equilibrium analysis, using opportunity cost and community indifference curves to determine the terms of trade effects of a tariff.

Johnson (1969) approached the standard theory of tariffs from both a normative and a positive perspective. Positive analysis is concerned with tariff effects on prices, factors of production, and terms of trade. By contrast, normative analysis focuses on the welfare implications of imposed tariffs and the optimal allocation of resources. There are different scenarios presented with different underlying assumptions, thus indicating varied effects of a tariff. Johnson further addressed issues relevant to tariffs imposed by the government under a free trade scenario and determined the welfare effects related to an optimum tariff rate, tariff retaliation, and tariff bargaining. He further approached tariffs using the traditional Heckscher-Ohlin model of international trade. The entire analysis is concerned with welfare effects of the tariff-imposing country.

Rieber (1981) contended that the effects of a tariff on combined producers' surplus and government tariff revenue would be less than the loss to consumers' surplus. He further demonstrated that as tariff rates increase, producers' marginal costs approach the world price, which induces producers to export their production surplus to foreign countries. This results in a higher domestic price, which inhibits consumption in the domestic market.

Ray (1981) developed a model premised on the notion that "subject to political constraints, trade restrictions are consistent with profit maximization across industries" to determine the tariff and nontariff barriers that would allow trade across industries in the United States. In most instances nontariff barriers supplement the level of tariff protection in the United States. The tariff and nontariff barriers were found in those industries whose structures and performance criteria had varied among market sectors. Ray concluded that both tariff and nontariff barriers were "biased toward industries in which the U.S. has an apparent comparative disadvantage in world trade and away from industries in which consumer welfare losses from protectionism would be great."

Welfare Losses

To determine the net effect of a tariff on the importing nation, we must aggregate the effects on consumption, production, and government revenues. In doing so, the production and consumption deadweight losses can be determined. This can be shown in the diagram provided by Lindert

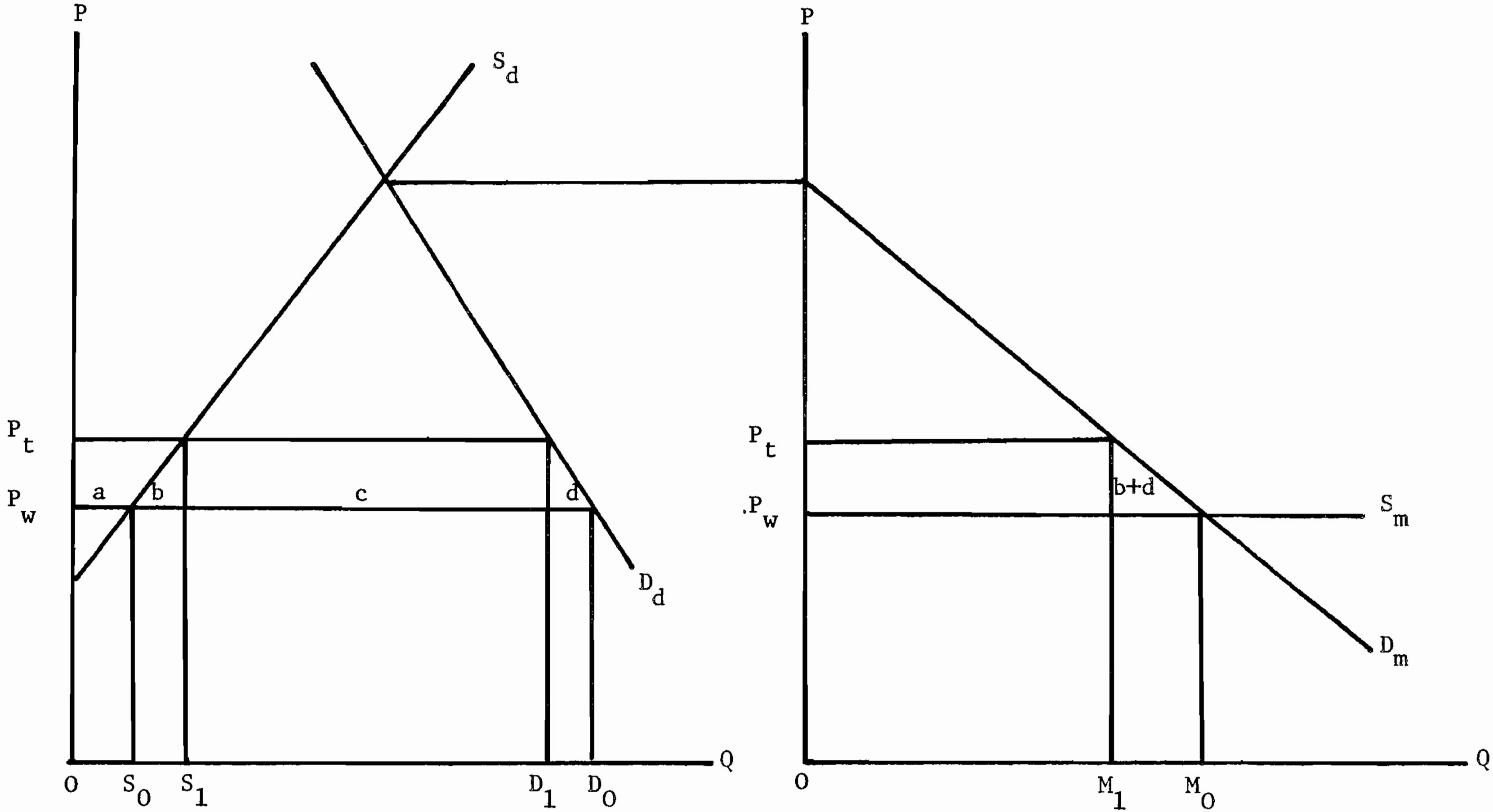

Figure 1. Welfare effects of a tariff.

and Kindleberger (1982) and Magee (1972), as shown in Figure 1. The demand for imports is derived by taking the difference ($D_d - S_d$) at each price to determine the actual amount of imports. At the outset, this shows the net welfare loss indicated by triangle $b + d$ in the right diagram, and thus depicted in the left diagram. Triangles b and d in the left diagram directly indicate the deadweight losses attributed to the production and consumption effects, respectively. The combined triangle ($b + d$) in the right diagram has as its height $OP_t - OP_w$ and as its base $OM_0 - OM$, representing the change in imports with the imposition of a specific or *ad valorem* tariff. The method used to measure the net welfare loss is to determine the tariff rate, the initial dollar value of imports, and the elasticity of demand for imports. This facilitates the determination of the estimated net welfare loss without the aid of domestic demand and supply curves. Implicit in this assumption is the notion of redistribution of consumers' losses in areas a and c, which are directly offset by producers' gains in area a and government revenue in area c.

Magee (1972) provided an equation to determine the elasticity of demand for imports:

$$e_m = (D/M)(e_d - e_s) + e_s$$

where e_m is the elasticity of demand for imports, e_d is the domestic demand elasticity, e_s is the domestic supply elasticity, D is the total quantity demanded in the United States, and M is the quantity of imports. To selectively solve the equation, Magee assumes a given import elasticity, then assumes e_d is zero, solves for e_s, and alternatively assuming e_s is zero, solves for e_d. Magee further concluded from his study that supply elasticity (e_s) exceeds demand elasticity (e_d) in absolute terms in both the short and long run. Although these elasticities may seem low and underestimate the welfare cost of a tariff, they are nonetheless valid. As a final note, Magee's calculation of the deadweight loss is facilitated with the formula $DWL = 0.5\ t^2 e_m V$, where t is the tariff rate, e_m is the elasticity of demand for imports, and V is the initial volume of imports.

Morkre and Tarr (1980) provided a comprehensive study of the welfare effects achieved with direct implementation of tariffs and quantitative restrictions on U.S. industries. Theoretical and applied analysis is provided in relation to protection and commercial policies and methods in measuring static, dynamic, and present values of the welfare effects from tariff and quota impositions. Their study indicated that welfare gains by eliminating a sugar duty of \$0.01875 amounted to \$450.6 million, and the welfare loss with the imposition of a \$0.05513 duty per pound of sugar was \$1281.1 million. When referring to the cost of labor adjustment, the study assumed that beet sugar producers could switch to alternative crops more readily than cane sugar producers. They further assumed that since Hawaii had a definite absolute advantage in higher yielding varieties, higher capital intensity, favorable weather conditions, and a workforce of 9000 full-time employees, it would be internationally competitive. Recent cost studies by Shapouri et al. (1982) indicated that the Hawaii sugar industry does not have this competitive advantage because of high wage and salary levels, higher costs attributed to repairs and maintenance, and other higher costs of production compared with mainland sugar-producing states. In this regard, Hawaii is not free of threats from foreign producers.

Mintz (1973) calculated the U.S. deadweight loss to production under a sugar quota arrangement ranging from \$79 to $110 million per year, and a consumption deadweight loss ranging from $10 to $25 million per year. The combined valuation of total deadweight loss thus ranged between $89 and $135 million. Additional estimates of a tariff equivalent revenue paid to foreign sources ranged between $265 and $317 million. The total annual average of the deadweight loss plus the tariff equivalent revenue amounted to $400 million. Morkre and Tarr concluded that estimates provided by Mintz demonstrated that "sugar policy based on duties is much less costly than a policy based on quotas."

Grubel (1971) provided a nontechnical exposition of the theory and policy implications of effective tariff protection in an attempt to simplify the development of concepts and arguments. The study presented the basic ideas of an effective tariff protection plan in relation to the notion of value added and the U.S. tariff schedule, nominal versus effective tariff rates, negative effects of taxes, and positive effects of subsidies on effective protection. The above principles are discussed in the context that input coefficients are fixed and that there are no adverse or zero effects of a general equilibrium model. He further addressed the implications relevant to the concept of effective protection, and its usefulness in policy formulation. The relevant area of focus was the extent to which tariffs and other government policies affected the direction and priorities of resource allocations. The flow of resources is towards those sectors where maximum protection is afforded. Grubel contended that "it should be noted that the welfare losses by consumers induced by tariffs and measured by the deadweight loss of consumers' surplus are not affected by the structure of tariffs and rates of effective protection for industrial purposes." Grubel provided further insight into why it was necessary to revise and relax the assumptions of (1) zero repercussion of tariffs in a general equilibrium context, and (2) fixed factor input proportions. With varable input proportions and recognizing general equilibrium repercussions, the net effect of tax structures allows for proportional changes in (1) value added per unit of output, (2) total value added for the entire industry, (3) primary factor price, and (4) gross output.

Supply Response

Jesse (1977) provided projections of sugarbeet acreage harvested under alternative pricing structures by using an econometric model of sugarbeet production. The prevailing price of $0.16 to $0.22 per pound was considered adequate to maintain sugarbeet production over the period 1976–1979. The proposed price and subsequent revenue obtained through alternative crops made a definite impact on present land allocations to sugarbeet production. The main competing alternative crops to sugarbeets were feed grains, cotton, wheat, and soybeans. It was concluded that if sugar prices continued below costs of production, there might be a more pronounced change to planting of alternative crops with higher potential returns. The study indicated geographical areas that would expand productive capacities to alternative crops, and targeted areas where production would remain constant and others where production would decline. A recursive model was provided to determine annual changes in acreage planted, production, and harvested acreage under different pricing schemes. A profit schedule was developed to reflect the prospective price changes for each of the alternative crops to sugarbeet production.

Zepp (1977) provided a normative profit-maximizing linear programming model to offer projections and measurements of supply response for sugarcane. The areas of study included Florida, Texas, and Louisiana, which are the only U.S. mainland cane-producing states. Although Hawaii was not included in the linear programming analysis, a separate analysis was conducted for Hawaii using cost and return data to estimate a supply response function. The linear programming approach allowed for the estimation of marginal cost functions, which further facilitated the determination of the level of raw sugar production that would be most profitable at alternative prices.

Nerlove (1958*a*) reiterated the notion that it is impossible to measure the short-run elasticity of supply and demand and suggested methods of measuring the estimated elasticities directly. The major emphasis lies with the formulation of dynamic models that will lead eventually to a distributed lag model. Nerlove contended that analyses based on dynamic models rather than static models would better facilitate reasonable regression coefficients with less serial correlation. He addressed the concept of expectations as the expected price or income one anticipated would prevail in subsequent periods. Following Hicks' definition of elasticity of expectation, the elasticity is set as equal to a constant and the equation is represented as follows:

$$Z_t^* - Z_{t-1}^* = B(Z_t - Z_{t-1}^*),\ 0 < B < 1$$

where B is the elasticity or coefficient of expectation, Z_t^* represents the expected level of a variable, Z_{t-1}^* represents the expected level of a variable in the previous period, and Z_t represents the actual level of the variable in period t.

The model's assumption is that individuals reformulate their expectations of what is normal based on the deviation between what they previously expected to occur and what actually occurred. If the coefficient of expectations is equal to one, one's expectations are static. If expectations are less than one, the expected price or income varies less than the actual. The notion of distributed lags was discussed in relation to the extent of full effects as a result of a change in price not felt immediately, but with its effects distributed over a specified time horizon. A dynamic model useful in estimating long-run elasticities is premised on the assumption of static expectations with existing prices and incomes, where quantity consumed would "change in proportion to the difference between the long-run equilibrium quantity and the current quantity." This assumption is represented by the following equation:

$$q_t - q_{t-1} = g(q_t^* - q_{t-1}),\ 0 < g < 1$$

where q_t^* is the quantity demanded in long-run equilibrium, q_t is the current quantity consumed, q_{t-1} is the quantity consumed in the previous period, and g is the constant of proportionality, or the coefficient of adjustment. The long-run demand function is represented in log-linear form as follows:

$$q_t^* = c + aP_t + by_t$$

where a is the long-run price elasticity, b is the long-run income elasticity, and c is the constant. Since long-run demand function cannot be observed, the following substitution is necessary:

$$q_t - q_{t-1} = g(c + aP_t + by_t - q_{t-1})$$
$$q_t - q_{t-1} = cg + agP_t + bgy_t - gq_{t-1}$$
$$q_t = cg + agP_t + bgy_t + (1 - g)q_{t-1}$$

which is not a demand function but a relationship of observable variables to facilitate the estimate. The coefficient of adjustment, g, is one minus the coefficient of q_{t-1}. The long-run price elasticity of demand may be obtained by dividing the coefficient of P_t by the coefficient of adjustment, ag/g, and the long-run income elasticity of demand is bg/g.

Nerlove and Addison (1958) in a companion article to Nerlove (1958*a*) presented a long-run supply curve based on the assumption that producers' decisions regarding production and acreage planted are premised on the previous year's price.

The acreage planted equation is represented as follows:

$$x_t^* = a + bP_{t-1} + ct$$

where x_t^* is planned long-run output, a is proxy for acreage planted, P_{t-1} is the relative price of the commodity, deflated by the index of prices received by farmers to reflect an alternative crop, and c is a constant. The supply adjustment equation is represented by:

$$x_t - x_{t-1} = g(x_t^* - x_{t-1}),\ 0 < g < 1$$

where x_t^* is planned long-run output, x_t is current planned output, and x_{t-1} is current planned output lagged one period. Since planned long-run output cannot be observed because of changes in prices, the following substitution is necessary:

$$x_t - x_{t-1} = g(a + bP_{t-1} + ct - x_{t-1})$$
$$x_t - x_{t-1} = ag + bgP_{t-1} + cgt - gx_{t-1}$$
$$x_t = ag + bgP_{t-1} + cgt + (1 - g)x_{t-1} + u_t$$

Thus, the equation is not a supply function but a relationship of observable variables to facilitate the estimate. The long-run price elasticity of supply is derived by dividing the coefficient of P_{t-1} by the coefficient of adjustment, bg/g. Nerlove concluded by emphasizing that if full adjustment is longer than the interval of observation on pertinent variables taken for the same period, little can be determined with regard to the probable long- and short-run elasticities.

Askari (1970) indicated that "sugar is not very price responsive, at least with respect to price decreases," and noted that with sector specialization in sugarcane and asset fixity in capital equipment, producers are especially reluctant to seek alternative crops. He further said that fixed costs in both cultivation and milling usually influence the producer's decision to remain in sugar production. Askari's model indicated that (1) changes in supply response reflected changes in prevailing prices, (2) use of output rather than yield as a dependent variable appeared to be a reliable indicator of the producer's commitments, (3) import quotas and tariffs were deemed to be exogenous variables, (4) inventory levels would be useful in assessing supply variability to price variability, (5) price expectations should be included to reflect two growing periods, (6) time trend should be included to reflect changes in technology, (7) ratooning should be considered independently with respect to lower cultivation costs, and (8) prices of alternative crops and acreage planted should be lagged one or two periods. Askari formulated a model to reflect traditional practices of using ratoon crops, but it was limited in application due to lack of secondary data sources.

The model used by Askari was a modified Nerlovian adjustment model represented as follows:

$$A_t^D = a_0 + D_1a_1P_1^e + D_2a_2P_t^e + a_3Y_t + a_4W_t + u_t$$
$$P_t^e - P_{t-1}^e = B(P_{t-1} - P_{t-1}^e)$$
$$A_t - A_{t-1} = G(A_t^D - A_{t-1})$$

where P_t is the actual relative price, P_t^e is the expected relative price, Y_t is the actual yield per acre, W_t is the weather index, and A_t^D is sugar acreage. D_1 and D_2 are dummy variables based on these criteria: D_1 is equal to 0 if $P_{t-1} - P_{t-2} > 0$, and equal to 1 if $P_{t-1} - P_{t-2} < 0$; D_2 is equal to 0 if $P_{t-1} - P_{t-2} < 0$, and equal to 1 if $P_{t-1} - P_{t-2} > 0$.

The estimated equation, which is a reduced form of this model, represented sugar acreage as a function of lagged one- and two-period relative prices, a ratio of sugar prices to rice prices, acreage, and current and lagged one-period yield and weather indexes. An alternative supply model reflects longer growth periods for sugar, thus replacing the one-year lags in price and acreage in the equation presented above with a two-year lag, with corresponding values of D_1 and D_2. Askari felt that the above equation and variables were not exact but nonetheless represented the state of the art in light of the limited data on total new plantings, area in production, and areas where ratoon stages were available. The only data available were acreage planted, acreage harvested, and yields with corresponding production levels. The data permitted estimations of total production by aggregating output from different ages of sugarcane and different yield levels over time. Askari contended that the model underestimated supply response, because it only reflected the farmer's response to price changes by adjusting total area planted and neglected to reflect variability in production attributed to mature sugarcane. He argued that the modified traditional Nerlovian price expectations equation was not appropriate, and he offered the following approved form:

$$P^e = P_{t-1} + B(P_{t-1} - P_{t-2})$$

Askari concluded that farmers responded to price incentives by increasing planted acreage devoted to sugarcane and improving the yield per acre.

METHODOLOGY

Price Support Program

The economic model for the study addresses two scenarios for the 1974–1981 period: (1) the actual situation under a free market environment and (2) a superimposed price support program. The price support program proposed in the second scenario is based on a weighted-mean average cost of production and processing for raw cane sugar in the United States. Transportation and refining charges are added to the cost of production for the four cane sugar–producing states for the 1981 crop year. The 1981 cost of production was deflated using the Producer Price Index to approximate the annual cost of production for 1974–1980.

The cost differential derived from the two scenarios provides a mean annual cost that would have been incurred by U.S. consumers to sustain the price support program during the study period.

The derived support program and the determination of its mean annual cost are the basis for the econometric procedures used in estimating linear and double logarithm demand functions, regression coefficients, their respective price elasticities, and demand differentials between the free market and price support scenarios.

Partial Adjustment Model

The partial adjustment model is used to estimate both short- and long-run price elasticities of linear and double logarithm demand and supply functions and the coefficient of adjustment when expressed in a double logarithm function. It provides information regarding actual levels of consumption and production and relates desired levels of consumption and production to changes in price. The coefficient of adjustment has a percentage between zero and one. The closer this adjustment factor is to one, the closer the estimated levels approximate the actual levels.

The demand function is specified as follows:

$$Q_t^d = f(P_t, P_o\ Y_t, T_t) \tag{1}$$

$$Q_t^{d*} = a_0 + a_1P_t + a_2P_o + a_3Y_t + a_4T_t + e_t \tag{2}$$

$$Q_t^d - Q_{t-1} = g(Q_t^{d*} - Q_{t-1}) \tag{3}$$

where

Q_t^{d*} = desired per capita quantity demanded in time t

Q_t^d = current per capita quantity demanded in time t

Q_{t-1} = per capita quantity demanded in time $t-1$

P_t = retail price of sugar in time t

P_o = retail price of alternative sweetener in time t

T_t = time trend

e_t = a random disturbance in time t

g = coefficient of adjustment

In order to facilitate the estimation of the parameters of the partial adjustment equation by using Ordinary Least Squares, the inclusion of equation (2) in equation (3) is necessary to establish a relationship between the dependent and independent variables, which include a lagged dependent variable.

The following equation is the result of the substitution and rearrangement of terms as discussed above:

$$Q_t^d = a_0g + a_1gP_t + a_2gP_o + a_3gY_t + a_4gT_t + (1-g)Q_{t-1} + ge_t + u_t$$

This simplified relationship, assuming a double logarithm function, provides short- and long-run elasticities. The coefficient of adjustment is equal to one minus the estimated coefficient of the lagged dependent variable, Q_{t-1}.

The supply function is specified as follows:

$$Q^s_t = f(P_{t-2}, PWAGE_{t-2}, PCROP_{t-2}, PFERT_{t-2}, T_t) \tag{4}$$

$$Q^{s*}_t = b_0 + b_1P_{t-2} + b_2\,PWAGE_{t-2} + b_3PCROP_{t-2} + b_4PFERT_{t-2} + b_5T_t + e_t \tag{5}$$

$$Q^s_t - Q^s_{t-1} = h\,(Q^{s*}_t - Q^s_{t-1}) \tag{6}$$

where

Q^{s*}_t = desired quantity raw sugar produced in time t

Q^s_t = current quantity raw sugar produced in time t

Q^s_{t-1} = current quantity raw sugar produced in time $t-1$

P_{t-2} = price paid to producers lagged two periods

$PWAGE_{t-2}$ = price of labor lagged two periods

$PCROP_{t-2}$ = price of alternative crop lagged two periods

$PFERT_{t-2}$ = price of fertilizer lagged two periods

T_t = technology

h = coefficient of adjustment

Following the procedure used for the demand equation, equation (5) is included in equation (6) to obtain the relationship between the dependent and independent variables, which includes a lagged dependent variable.

The resulting equation is as follows:

$$Q^s_t = b_0h + b_1hP_{t-2} + b_2hPWAGE_{t-2} + b_3hPCROP_{t-2} + b_4hPFERT_{t-2} + b_5hT_t + (1-h)Q^s_{t-1} + he_t + u_t$$

This simplified relationship, assuming a double logarithm function, provides short- and long-run elasticities. The coefficient of adjustment h indicates the degree of response of producers to changes in price.

Distributed Lag Model

The distributed lag model is used to determine the probable price lag that producers respond to in periods of price variability. The model is useful to further determine producers' intentions with respect to acreage scheduled for planting under the two price scenarios. The analysis covers each of the four sugarcane-producing states and aggregates the sugarbeet-producing states. The exogenous variables are prices in the free market and in the price-administered scenario. The predetermined variables are acreage planted and acreage harvested. The acreage response function is specified as follows:

$$X_t = f(P_{t-1}, P_{t-2}, P_{t-3}, P_{t-4}, T_t, D) \quad (7)$$

$$X_{t^*} = a_0 + a_1P_{t-1} + a_2P_{t-2} + a_3P_{t-3} + a_4P_{t-4} + a_5T_t + a_6D + u_t \quad (8)$$

$$X_t - X_{t-1} = g(X_{t^*} - X_{t-1}) \quad (9)$$

where X_{t^*} = desired acreage planted or harvested, X_t = current acreage planted or harvested, X_{t-1} = current acreage planted or harvested in time $t-1$, P_{t-1} = price of sugar in time $t-1$, P_{t-2} = price of sugar in time $t-2$, T_t = technology, and D = binary variable is equal to one if 1974–1981 and zero otherwise.

By including equation (8) in equation (9), the acreage response function is expressed as:

$$X_t - a_0g + a_1gP_{t-1} + a_2gP_{t-2} + a_3gP_{t-3} + a_4gP_{t-4} + a_5gT_t + a_6gD + gu_t + (1-g)X_{t-1} + e_t$$

The rationale for lagged prices is to reflect the biological delay between planting, or initial growth period, to harvesting of 12 to 24 months.

Partial Equilibrium Model

The primary methodology used in measuring welfare effects of the imposition of a tariff is a partial equilibrium model. The main focus of a partial equilibrium analysis is to derive linear demand and supply equations and to assess consumers' surplus, producers' surplus, tariff revenues, imports, and deadweight loss in consumption and production to society.

The following *a priori* assumptions are relevant to this model:

(1) Linear demand and supply functions.

(2) The production of sugar in the United States is perfectly competitive, and firms seek to maximize profits.

(3) The elasticity of foreign supply is infinitely elastic.

(4) Money income is constant.

(5) Price and capital valuation is constant.

(6) The domestic production of U.S. sugar is homogeneous with foreign imports and a perfect substitute for imported sugar.

(7) The domestic consumption and production increase and decrease with the imposition of a tariff, indicating movements along demand and supply curves.

(8) Demand and supply curves are static.

The diagram in Figure 2 is a general representation of the partial equilibrium model.

The foreign supply curve of foreign imports is $S_fS_{f'}$, with $O - S_f$ representing the free market price of imports. This free market price includes costs of production, insurance, and freight. The domestic supply curve is $S_dS_{d'}$, representing the rising portion of the marginal cost curve of the firm. The domestic demand curve is $D_dD_{d'}$, representing an aggregate of domestic production and imports. At the free market price of $O - S_f$, domestic production is OA and domestic consumption is OB, which includes domestic production plus foreign imports.

Two tariff scenarios are imposed in the analysis: (1) specific tariff rate per unit of sugar imported, and (2) an *ad valorem* tariff rate. Imposition of either type of tariff, assuming a perfectly elastic supply,

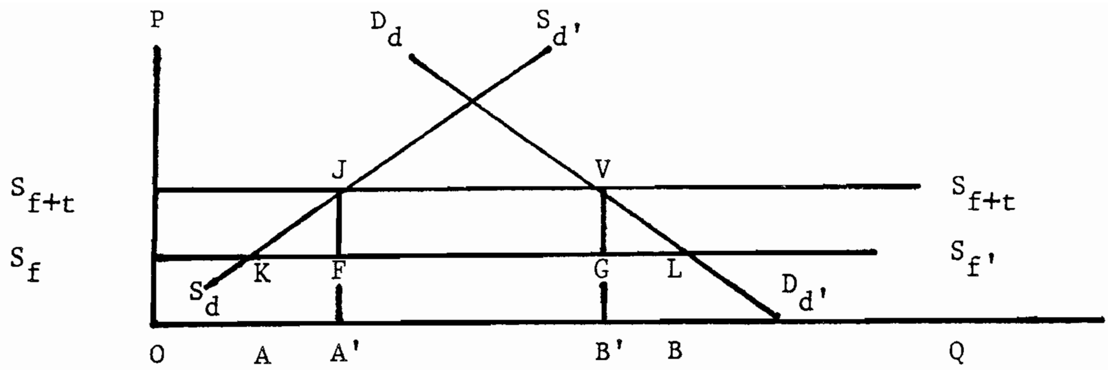

Figure 2. Partial equilibrium model: welfare effects.

results in an increase in price from S_f to S_{f+t} (Figure 2). This increase in price stimulates production at the domestic level to *OA′* and reduces consumption by *BB′*. This movement along the demand and supply curves represents a reduction in imports by the increase in production *AA′* and a decrease in consumption *BB′*, resulting in imports *A′B′*. The corresponding revenue generated is the area *FJVG*.

The following welfare effects result from the imposition of a tariff:

(1) Production effect: domestic output increases by *AA′*.

(2) Consumption effect: domestic consumption decreases by *BB′*.

(3) Import or balance of payment effect: imports decrease from *AB* to *A′B′*.

(4) Revenue effect: tariff revenue is reapportioned to the government.

(5) Redistribution effect: income is redistributed from the consumer to the government and domestic producers.

(6) Production deadweight loss: production inefficiency is *KFJ*.

(7) Consumption deadweight loss: consumption inequity is *GLV*.

The redistribution effect in the form of a subsidy to domestic production per unit produced is represented by S_fS_{f+t}. The total output of *OA′* is represented by the area $S_fS_{f+t}JF$. If government policy provided a production subsidy for sugar producers, it would be equal to $S_fS_{f+t}JF$, known as the subsidy-equivalent of a tariff.

The partial equilibrium model comprises the following implicit demand function:

$$Q_t^d = f(P_t, P_o, Y_t, T_t)$$

where Q_t^d is the per capita demand for sugar in time *t*, for a given retail price, P_t, price of other corn sweeteners, P_o, income, Y_t, and trend, T_t. The structural equation is specified as follows:

$$Q_t^d = a_0 + a_1P_t + a_2P_o + a_3Y_t + a_4T_t + u_t$$

The assumed linear demand equation provides an estimated price elasticity of demand at the means, which is used in determining the welfare effects of the imposition of a tariff.

The coefficient a_1 is expected to have a negative sign, since economic demand theory indicates an inverse relationship between quantity demanded and price. The coefficient a_2 is expected to have a negative sign if the competing good is a complement and a positive sign if the alternative sweetener is a substitute. The coefficient a_3 is expected to have a positive sign, since there is a positive relationship between income and quantity demanded. The coefficient a_4, related to trend, is expected to be reflected as a negative relationship between changes in preferences over time.

The implicit function related to supply is as follows:

$$Q_t^s = g(P_{t-2}, PWAGE_{t-2}, PCROP_{t-2}, PFERT_{t-2}, T_t)$$

where Q_t^s is the quantity of sugar produced in time t, P_{t-2} is the market price of sugar in time $t-2$, $PWAGE$ is the prevailing wage rate in time $t-2$, $PCROP$ is the price of a competing crop, T_t trend is a proxy for technology, and $PFERT_{t-2}$ is the price per ton of fertilizer.

The structural equation is as follows:

$$Q_t^s = b_0 + b_1P_{t-2} + b_2PWAGE_{t-2} + b_3PCROP_{t-2} + b_4PFERT_{t-2} + b_5T_t + u_t$$

The equation is assumed to be linear and provides an estimated price elasticity of supply at the means, which is used in determining the welfare effects of the imposition of a tariff.

The coefficient b_1 is expected to have a positive sign, which suggests a positive relationship between price and quantity supplied. The coefficient b_2 has a negative sign, which postulates a negative relationship between wage rate and quantity supplied. The coefficient b_3 is expected to have a negative sign, since there is an inverse relationship between the price of an alternative crop and quantity supplied. The coefficient b_4 is expected to have a negative sign, since there is an inverse relationship between price of fertilizer and quantity supplied. The coefficient b_5 is expected to have a positive sign, which postulates a positive relationship between technology and quantity supplied.

Welfare Analysis

Determinations of welfare costs and benefits of government protection policies for restricting the flow of imported sugar are measured in this analysis through a partial equilibrium model. The basis for these empirical determinations is reflected in changes in consumers' and producers' surplus, government revenues, foreign imports, production deadweight loss, and consumption deadweight loss.

The method of welfare analysis is patterned after that provided by Morkre and Tarr (1980):

$$DWLC = ½(t_a \,/\, 1 + t_a)^2\,(n_d)\,(V_d)$$

where $DWLC$ = deadweight loss – consumption, t_a = specific or *ad valorem* tariff rate, n_d = price elasticity of domestic demand, and V_d = initial value of domestic consumption.

The deadweight loss in consumption is equal to one-half the product of change in the quantity consumed times the change in price times the price elasticity of demand times the initial consumption. The magnitude of $DWLC$ is directly related to the price elasticity of demand. If the price elasticity of demand is inelastic the $DWLC$ will be small, and if the price elasticity is elastic the $DWLC$ will be large.

$$DWLP = ½(t_a \,/\, 1 + t_a)^2\,(n_s)\,(V_s)$$

where $DWLP$ = deadweight loss – production, t_a = specific or *ad valorem* tariff rate, n_s = price elasticity of domestic supply, and V_s = initial value of domestic production.

The deadweight loss in production is equal to one-half the product of change in the quantity produced times the change in price times the price elasticity of supply times the initial production.

Time Horizon

Since the implementation of the Jones-Costigan Act of 1934 and subsequent renewals and inclusions of price supports for sugar in various Agriculture and Food Acts, prices of sugar have been relatively stable through 1973. The period after 1973 was characterized by unusually high prices in 1974, 1975, and 1980 and extremely low prices from 1976 through 1979. Two time periods were used in the study, the first period using time-series data for demand and supply analysis from 1955 through 1973, and the second period from 1955 through 1981. The main concern is that there exists slight variability in price, quantity demanded, and quantity produced from 1955 through 1973. The period 1974-1981 is unique in that there existed an essentially free market situation that exhibited substantial price variation. It was concluded that it would be beneficial to include this eight-year period in the model to determine a causal relationship of change in consumption and in production capacity.

Data Sources

Time-series data were used to determine the estimates of demand, supply, and acreage response regression coefficients. Most of the data necessary for the analysis were obtained from the following sources: USDA Agricultural Statistics; USDA Sugar and Sweetener Outlook and Situation Report; USITC Report to the President; USDC Bureau of Labor Statistics; Food and Agriculture Organization of the UN, Bulletin of Agricultural Economics and Statistics; F. O. Licht's International Sugar Report (Ahlfeld); USDA Agricultural Outlook; USDA Agricultural Prices; HPED Data Book; HSPA Hawaiian Sugar Manual; and HDOA Statistics of Hawaiian Agriculture. These reports provide data on weekly, monthly, quarterly, and annual bases. The data used in the analysis were obtained on an annual basis for the time period 1955-1981. The data were used to reflect average prices in nominal terms, and were deflated when appropriate to reflect prices in real terms.

PRICE SUPPORT PROGRAM 1974-1981

Introduction

The objectives of this section are to model a price support program that would have been effective if the Sugar Act of 1948 had not been allowed to expire in 1974, and to determine the cost of this program to U.S. consumers if it had been administered. The annual per capita expenditure by consumers is based on aggregated industrial and nonindustrial sugar consumption, which facilitates a comparison of per capita expenditures under both price scenarios. The cost differential derived from the two scenarios provides a mean annual cost that U.S. consumers would have incurred to sustain the price support program for this period.

Price Support Program

The primary basis for the proposed price support program imposed on the 1974-1981 period is a weighted mean cost of production for raw sugar based on a study conducted for the U.S. Department of Agriculture by Shapouri (1982) and subsequently updated by Angelo (1983). The Shapouri study obtained a weighted price for U.S. cane sugar based on the respective percentage of production of raw sugar by each state to total cane sugar production in 1981. Refining and transportation costs plus a 34 percent markup for manufacturing, wholesaling, and retailing were added to the mill price of raw sugar to determine the price to the consumer. The valuation of cash lease rent and management fees is based on market values of prime agricultural land and management salaries. The mean cost of production for 1981 was deflated back to 1974, using the annual percentage change in the Producer Price Index to reflect the increases attributable to inflation for the period 1974-1981.

Land and management charges as suggested by Angelo (1983) are included in the cost of production, which is the basis for the determination of the Market Stabilization Price (MSP) attributable to a specified crop year. Land charges are determined by taking a fixed percentage of the assessed market value of prime agricultural land, which is used to assimilate cash lease rent. The lease rent charged in cane sugar production is the annual charge per acre of dedicated land for the production of cane sugar. In Hawaii, a flat percentage of gross plus a basic annual fee is charged per acre in the analysis. However, in some instances under actual conditions, landowners charge a basic annual fee plus a specified percentage of the gross revenue earned in a specific crop year. The proposed land charges represent the expected rate of return to investors and owners having vested interest in the parcels of land dedicated to the production of cane sugar.

Assumptions

The price support program superimposed during the study period 1974–1981 interrelates with demand and supply in determining purchases, quantity supplied, and acreage. It is the basis for the determination of the approximate revenue-equivalent price of the ingredient of sugar used in the industrial sector. The categories of industrial users of sucrose are (1) bakery and cereal, (2) confectionery, (3) processed foods, (4) dairy products, (5) beverage, and (6) other. The nonindustrial categories are: (1) institutions, (2) eating and drinking establishments, (3) deliveries to government agencies and military, (4) pharmaceuticals and tobacco, (5) wholesalers, and (6) retailers. It was determined that the value added by manufacturers, wholesalers, and retailers combined is approximately 34 percent of the wholesale cost of refined and liquid sugar. This estimated margin is used as a markup factor on the base support price of refined sugar on a per pound basis. The estimates of per capita consumption are derived from the time-series data provided by the USDA on per capita consumption of sugar and the aggregate level of the number of tons delivered to the industrial and nonindustrial sectors. Allocation of the utilization of sugar by the industrial and nonindustrial sectors was determined to be 75 and 25 percent, respectively. The amount of sugar consumed by the industrial sector represented in tons is multiplied by the retail price per ton to determine the retail equivalent value of sugar used in the industrial sector. Similarly, the amount of sugar consumed in the nonindustrial sector is multiplied by the retail price per ton to determine the retail equivalent for sugar. The summation of the retail price–equivalent expenditures for the industrial and nonindustrial sectors represents the total annual expenditures for each of the years 1974–1981. To determine the total expenditure for the eight-year period all eight years were aggregated.

The same procedure was developed for the free market scenario to compare this scenario with the total expenditures under the support program. Free market prices in the analysis consisted of the actual New York Spot Price, wholesale price, and retail price for the period. This comparison of the two price scenarios consisting of a theoretically determined price support program and the free market situation provides an indication of the magnitude in dollars expended per capita under the support program in order to sustain sugar producers. The prices derived in this cost comparison in the two scenarios are reflected in nominal prices, since the values on a per ton basis were not deflated. The general conclusion accepted when considering a support program is that the consumer will eventually bear the burden of overall price increases to cover the costs of production of cane and beet producers. In this instance, the indicated annual per capita increase in price to be borne by the consumer as an added expenditure to provide price stablity to the sugar industry is $4.77. This increase may be added to the estimated annual per capita expenditure for sugar of $28.50 during the 1974–1981 period without the superimposed price support program to estimate the annual per capita cost of sugar under the support program.

A comparable price support program to that for cane sugar is programmed for sugarbeet producers for the support scenario that would have ensured an adequate net farm revenue and adequate return to investors. The cane or beet producers' decision to make the transition to alternative crops and assume the risk of new crops is premised on price expectations and price stability in future years. An important consideration in acreage response by beet producers is that of peak prices in 1974 and 1980 and lower prices in the interim years. In order for sugarbeet producers to expand acreage they must be assured of adequate slicing and processing plant capacities. Historically, many of the beet-producing areas have decreased acreage dedicated to beet production because of the lack of adequate processing facilities. If the prices of sugar and its by-products do not provide an equitable expected rate of return to beet producers, they are compelled to divest sugar lands in favor of alternative crops. In many instances, however, there are no viable alternatives.

The USDA has conducted numerous cost-of-production studies for both cane and beet sugar to be used in determining the appropriate price support level at which to sustain producers. This level of price support is intended to sustain producers in the industry, but not to encourage inordinate expansion in sugar production. The impact of price supports for sugar may adversely affect price support programs of other agricultural commodities. An important consideration is the effect of the price support for sugar on the corn industry. Price supports for sugar may, for example, increase the market share of alternative caloric and corn sweeteners in industrial and nonindustrial sectors. If this occurs, it adds to the growing surplus of sugar stocks presently in storage. The price of corn sweeteners at the time this study was conducted was less than 70 percent of that of sugar. This low price plays an important role in decreasing the variable cost of production for the manufacturing industry. There is a technological limitation, however, as corn sweeteners cannot be crystallized with existing technology and thus cannot generally be used for table sugar and for bakery products, i.e., breads and cakes. The crystalline properties of sugar make it a necessary ingredient in cakes and cookies in order to fully provide and incorporate air into the product for leavening purposes. Until technology in crystallizing corn sweeteners is developed, sucrose, with its unique properties, will remain an important ingredient in bakery products.

Weighted Cost of Production

The U.S. cost of production and processing of cane sugar in this analysis as a basis for target price and loan rates is weighted by the share of production of the respective sugarcane-producing states in 1981 (Table 1).

The implicit function to obtain the weighted cost of production for raw cane sugar is $WCOP = f(\text{cost of production}_i, \text{share of production}_i)$, where $WCOP$ =

weighted cost of production. The structural equation is as follows:

$$WCOP_{US} = COP_{FLA} * SOP_{FLA} + COP_{LA} * SOP_{LA} + COP_{TX} * SOP_{TX} + COP_{HI} * SOP_{HI}$$

where $WCOP$ = weighted mean cost of production, COP_i = cost of production in the ith region, and SOP_i = percent share of production in the ith region.

Inherent in the costs of production is the inclusion of land charges in the support program. The basis for the land charge is an estimated annual cost lease rent, which is determined by taking a fixed percentage of the fair market value of prime agricultural land at its highest and best use value. This specified percentage is the expected return to equity under optimal use value.

Calculations for the weighted cost of production per pound of raw sugar in 1981 based on data in Tables 1 and 2 are as follows:

$$\begin{aligned} WCOP_{US} &= (23.34 \times .358) \\ &\quad + (18.06 \times .257) \\ &\quad + (21.62 \times .043) \\ &\quad + (23.09 \times .342) \\ &= 8.35 + 4.64 + .93 + 7.90 \\ &= 21.82 \text{ cents} \end{aligned}$$

The weighted derived support price is compared with the cost of production for each of the sugarcane-producing regions in Table 3. The cost differential ranges from −1.52 cents for Florida to +3.76 cents for Louisiana, thus indicating that Louisiana may benefit more from the price support program than other cane-producing states.

The computed 1981 support price per pound for raw sugar amounts to 24.93 cents, based on a weighted mean production and processing cost of 21.82 cents plus a weighted mean transportation cost of 3.11 cents per pound. This price was added to the cost of refining to determine the total 1981 cost of refined sugar f.o.b. refinery of 29.79 cents per pound. An estimated margin of 34 percent (4 percent manufacturer, 9 percent wholesaler, and 21 percent retailer) was used to convert this cost to the retail price to the consumer of 39.92 cents per pound in 1981 (Table 4). Conversion to the retail price permitted computation of the cost of sugar as an ingredient in the industrial and nonindustrial sectors on a common per capita basis for comparing the free market and price support scenarios.

Under the assimilated price support program in the analysis, the retail price ranged from 29.89 cents in 1976 to 39.92 cents in 1981 (Table 4). Free market prices exceeded support prices during 1974, 1975, and 1980; thus the free market prices of 44.27, 34.86, and 46.71 cents, respectively, are used for both price scenarios (Table 4).

The estimated mean annual expenditure for sugar at the retail level during the 1974–1981 period under the free market scenario amounts to $6.2 billion, of which $4.7 billion is for industrial use and $1.5 billion for nonindustrial use (Table 5). The mean annual expenditure under the free market scenario is $7.2 billion, of which $5.5 billion is for industrial use and $1.7 billion is for nonindustrial use (Table 5).

On a per capita basis, mean annual expenditure during the 1974–1981 period amounts to 27.83 cents under the free market scenario and 32.60 cents under the simulated price support program (Table 5). Thus the additional annual cost to consumers to administer the price support program amounts to $4.77 annually.

Sugar Demand Functions

The quantity of sugar (sucrose) demanded on a per capita basis by U.S. consumers is a function of retail price and personal consumption expenditures, which are deflated by the Consumer Price Index (CPI) for conversion to real terms. Sugar

Table 1. Costs of Production and Processing of Sugarcane in the United States by State, 1981 Crop Year

State	Production Cost Per Net Ton Sugarcane	Processing Cost Per Net Ton Sugarcane	Production & Processing Cost Per Net Ton Sugarcane	Total Credits Per Net Ton Sugarcane
Florida	$33.28	$16.22	$49.50	$2.34
Hawaii	35.33	23.31	58.64	3.86
Louisiana	21.86	18.52	40.38	1.70
Texas	22.26	20.88	43.14	1.94
United States	30.58	19.41	49.99	2.67

State	Production Cost Per Pound Raw Sugar	Processing Cost Per Pound Raw Sugar	Production & Processing Cost Per Pound Raw Sugar	Total Credits Per Pound Raw Sugar
Florida	$0.1647	$0.0803	$0.2450	$0.0116
Hawaii	0.1489	0.0983	0.2472	0.0163
Louisiana	0.1021	0.0865	0.1886	0.0079
Texas	0.1168	0.1095	0.2263	0.0102
United States	0.1412	0.0896	0.2309	0.0123

State	Net Production & Processing Cost Per Net Ton Sugarcane	Net Production & Processing Cost Per Pound Raw Sugar
Florida	$47.16	$0.2334
Hawaii	54.78	0.2309
Louisiana	38.68	0.1806
Texas	41.20	0.2162
United States	47.32	0.2185

Source: Angelo, L., and F.L. Hoff, "U.S. Sugarbeet and Sugarcane Production and Processing Costs - 1981 Crop." Sugar and Sweetener Outlook and Situation, U.S.D.A., SSR Vol. 8, No. 3, September, 1983, pp. 11-19.

Table 2. Domestic Sugar: Acreage Harvested, Yield per Acre, and Production of Sugarcane for Specific Producing States, 1981

State	Sugarcane Harvested Acreage 1000 Acres	Sugarcane Yield Per Harvested Acre, Tons	Sugarcane Production 1000 Short Tons	Percent Share of Production
	(Acres)	(Tons)	(Tons)	(Percentage)
Cane Areas:				
Florida	348.2	28.5	9,924	35.8
Louisiana	265.0	26.9	7,129	25.7
Texas	37.4	31.5	1,178	4.3
Hawaii	104.8	90.5	9,484	34.2
Total U.S. Industry	755.4	36.6	27,715	100.0

Source: Angelo, L., and F.L. Hoff, "U.S. Sugarbeet and Sugarcane Production and Processing Costs - 1981 Crop." Sugar and Sweetener Outlook and Situation, U.S.D.A., SSR Vol. 8, No. 3, September, 1983, pp. 17, 26.

Table 3. Weighted Cost of Production and Regional Cost of Production Differential, United States, 1981 (cents per pound of raw sugar)

	WCOP Cents/#	COP Cents/#	COP Differential Cents/#
Florida	21.82	23.34	- 1.52
Hawaii	21.82	23.09	- 1.27
Louisiana	21.82	18.06	+ 3.76
Texas	21.82	21.62	+ .20

Table 4. Free Market and Price Support Retail Price of Sugar in Cents per Pound, United States, 1974-1981

	1974[a]	1975[a]	1976	1977	1978	1979	1980[a]	1981
Free Market								
N.Y. Spot Price	$0.2950	$0.2247	$0.1331	$0.1100	$0.1393	$0.1556	$0.3011	$0.1973
Refining Costs	0.0354	0.0355	0.0364	0.0367	0.0405	0.0460	0.0475	0.0486
Total	0.3304	0.2602	0.1695	0.1467	0.1798	0.2016	0.3486	0.2459
Total Retail	0.4427	0.3486	0.2271	0.1965	0.2409	0.2701	0.4671	0.3295
Price Support Program								
WCOP US	$0.2950	$0.2247	$0.1634	$0.1647	$0.1818	$0.2065	$0.3011	$0.2182
Transportation	b/	b/	0.0233	0.0234	0.0259	0.0294	b/	0.0311
Refining Costs	0.0354	0.0355	0.0364	0.0367	0.0405	0.0460	0.0475	0.0486
Total	0.3304	0.2602	0.2231	0.2248	0.2482	0.2819	0.3486	0.2979
Total Retail	0.4427	0.3486	0.2989	0.3023	0.3326	0.3778	0.4671	0.3992

a/ Prices during years 1974, 1975, and 1980 are the same under the price support program as under the free market program since the free market price exceeds the support price.

b/ Transportation cost is not shown for years 1974, 1975, and 1980 because it is only used in estimating support prices in years in which support prices prevail.

Table 5. Retail Value of Sugar for Industrial and Nonindustrial Sectors, United States, 1974-1981

Year	Price/Ton	Retail Value Industrial (1000 dollars)	Retail Value Nonindustrial (1000 dollars)	Total Expenditure (1000 dollars)
Free Market Scenario				
1974	$885.46	$7,046,491	$1,669,390	$8,715,881
1975	697.32	4,786,404	1,793,744	6,580,148
1976	454.26	3,454,647	1,168,769	4,623,416
1977	393.14	3,102,268	1,063,704	4,165,972
1978	481.86	3,739,234	1,073,198	4,812,432
1979	540.20	4,068,067	1,199,216	5,267,283
1980	934.24	6,664,868	2,006,216	8,671,084
1981	659.01	4,472,633	1,940,000	6,412,633
Total		$37,334,612	$11,914,237	$49,248,849
Annual Mean Value		4,666,827	1,489,280	6,156,106
Total Annual Per Capita Expenditure (Pop. 221,226,000)		$21.10	$ 6.73	$27.83
Support Scenario				
1974	$885.46	$7,046,491	$1,669,390	$8,715,881
1975	697.32	4,786,404	1,793,744	6,580,148
1976	597.98	4,547,702	1,450,815	5,998,517
1977	602.69	4,755,862	1,471,129	6,226,991
1978	665.27	5,162,556	1,404,633	6,567,189
1979	755.73	5,686,116	1,612,242	7,298,358
1980	934.24	6,664,868	2,006,216	8,671,084
1981	798.07	5,416,550	2,218,827	7,635,377
Total		$44,066,549	$13,626,996	$57,693,543
Mean Value		5,508,319	1,703,375	7,211,693
Annual Per Capita Expenditure		$24.90	$ 7.70	$32.60
Annual Per Capita Differential: Support-Free Market		$ 3.80	$ 0.97	$ 4.77

price and consumer income have negative and positive effects, respectively, on the quantity demanded. An increase in the price of substitute high fructose corn syrup was expected to have a positive effect on the quantity of sucrose demanded. However, preliminary analysis of the data indicated that the sign of the regression coefficient of the price of high fructose corn syrup was negative, indicating that an increase in the price of high fructose corn syrup would have an inverse effect on the demand for sugar. Since the price of high fructose corn syrup did not exhibit the expected relationship to sugar, it was excluded from the analysis.

The demand analysis for sucrose as applied to the period 1955–1981 is represented by two functional forms: (1) linear and (2) double logarithm functions. The linear function is included to permit comparison of its point elasticities with constant elasticities of the double logarithm function.

The linear function is:

$$QDUS = 100.75 - 41.298\, PSUCPI + 0.174\, PCECPI$$

where $QDUS$ = current per capita consumption of sugar (sucrose) in pounds, $PSUCPI$ = retail price of sugar per pound deflated by CPI, and $PCECPI$ = personal consumption expenditure deflated by CPI (Table 6).

Both own-price elasticity and income elasticity for the linear functional form are indicated to be highly inelastic, amounting to −0.0746 and −0.0625, respectively.

Table 6. Actual Quantity of Sugar Demanded, Retail Price, Personal Consumption Expenditure, United States, 1955-1981

Variable	Linear
Dependent	QDUS
PSUCPI	- 41.298
Asymptotic T-Ratio	- 4.5895 a/
PCECPI	0.17427
Asymptotic T-Ratio	4.5734 a/
Constant	100.75
Asymptotic T-Ratio	64.687
Durbin-Watson	2.089 b/
Own-Price Elasticity	- 0.07463
Income Elasticity	0.06245

a/ 5 percent level of significance
b/ Zero autocorrelation at the 5 percent level

The double logarithm function expressed in a partial adjustment context is:

$$LNQDUS = 1.3881 + 0.3881\ LNQDLAG - 0.0782\ LNPSU - 0.2292\ LNPCE + 0.0394\ ZLNPSU$$

where *LNQDUS* = per capita consumption of sugar, *LNQDLAG* = per capita consumption of sugar in the $t-1$ period, *LNPSU* = retail price of sugar deflated by CPI, *LNPCE* = per capita consumption of sugar deflated by CPI, and *ZLNPSU* = slope differential during the period of study (Table 7).

The demand elasticities for the double logarithm equation are determined with the use of a partial adjustment model's coefficient of adjustment. The elasticities for the short run can be read directly from each of the coefficients of the price variable. Short-run own-price elasticities amount to -0.78 for 1955–1973 and a much lower -0.04 for 1974–1981. Short-run income elasticity for 1955–1981 amounts to 0.23 (Table 7). The partial adjustment model determines the desired level of sugar consumed in relation to the actual level consumed. This coefficient of *LNQDLAG* is the contribution to the present level of

Table 7. Partial Adjustment Model: Actual Quantity of Sugar Demanded, Retail Price, Personal Consumption Expenditure, United States, 1955-1981

Variable	Double Logarithm
Dependent	LNQDUS
LNQDLAG	0.3881
T-Ratio	3.107 a/
LNPSU	- 0.0782
	- 2.075 a/
LNPCE	- 0.2292
	- 2.365 a/
ZLNPSU	0.0394
	4.028 a/
Intercept	1.387
	1.399
R-Square	0.7411
Durbin's h statistic	1.4865 b/
Own-price elasticity	
1955-1973 short-run	-0.0782
1974-1981 short-run	-0.0388
1955-1973 long-run	-0.1278
Income elasticity, short-run	0.2291
long-run	0.3744

a/ 5 percent level of significance
b/ Zero autocorrelation at the 5 percent level

Table 8. Estimated Demand Differential for Sugar Under a Free Market and Under a Price Support Program, Pounds per Capita, United States, 1974-1981

Estimated Equation: Partial Adjustment Model

LNQDUS = 1.387 + 0.388 LNQDLAG -0.0782 LNPSU - 0.229 LNPCE + 0.0393 ZLNPSU

Year	Observed Value Natural Logarithm	Estimated Demand Free Market	Estimated Demand Price Support	Estimated Demand Differential	Observed Value Natural Antilogarithm	Estimated Demand Free Market	Estimated Demand Price Support	Estimated Demand Differential
1974	4.5602	4.5008	4.5008	-0-	99.683	90.089	90.089	-0-
1975	4.4898	4.4905	4.4905	-0-	89.032	89.166	89.166	-0-
1976	4.5369	4.4829	4.4743	+ 0.0086	93.400	88.490	87.733	- 0.757
1977	4.5454	4.5090	4.4960	+ 0.0130	94.198	90.830	89.657	- 1.173
1978	4.5152	4.5479	4.5551	- 0.0072	91.395	94.433	95.116	+ 0.683
1979	4.4920	4.4858	4.4676	+ 0.0182	89.299	88.747	87.147	- 1.600
1980	4.4578	4.4829	4.4829	-0-	86.297	88.490	88.490	-0-
1981	4.3758	4.4720	4.4746	- 0.0026	79.439	87.531	87.759	+ 0.228

consumption as a direct result of consumption in the previous period. The long-run elasticities for own-price and income under the partial adjustment model are determined by dividing the short-run elasticities by lambda. The value of lambda is equal to .6119 (1.0 − .3881) for 1955–1981. Long-run elasticities amount to −0.13 for own-price and 0.37 for income, both of which are highly inelastic, indicating that sugar consumption is comparatively insensitive to changes in price or income.

Given the demand analysis under the partial adjustment model for per capita consumption of sugar in the United States in 1955–1981 under the free market scenario, demand under the support program was estimated for the period 1974–1981. In order to compute the estimated demand under the price support program, actual retail prices were substituted for estimated support prices in the double logarithm function:

$$
\begin{aligned}
LNQDUS &= 1.387 \\
&\quad + .3881\ LNQDLAG \\
&\quad - 0.0782\ LNPSU \\
&\quad - 0.2292\ LNPCE \\
&\quad + 0.0393\ ZLNPSU \\
&= 1.387 + .388\ (9.3439) \\
&\quad - 0.0782\ (-1.6254) \\
&\quad - 0.2292\ (2.4970) \\
&\quad + 0.0393\ (-1.6254) \\
&= 1.3876 + 3.6263 \\
&\quad + 0.1272 - 0.5722 \\
&\quad - 0.06396 \\
LNQDUS &= 4.5008 \text{ (Table 8)} \\
QDUS &= \text{antilog}_e\ 4.5008 \\
&= 90.089 \text{ pounds per capita for 1974 (Table 8).}
\end{aligned}
$$

The estimated per capita consumption under the price support scenario is the same as for the free market scenario in 1974 because the free market price exceeded the support price (Table 8). In 1976, however, where the support price exceeds the free market price, per capita consumption is 0.757 pound less under the price support scenario (Table 8).

This procedure was used to estimate demand for the subsequent years 1975–1981. The only change would be prices inherent in the price support program. In reviewing Tables 7 and 8, it can be concluded that the difference in prices in the two scenarios would have made a minimal difference in per capita consumption. The estimated demand differential is the difference between demand in the price support program and demand under the free market scenario.

Summary and Implications

This section provides a price support program for U.S. sugar based on an average weighted cost of production superimposed on the period 1974–1981. The support price determined for the 1981 crop year was $0.2182 per pound, a price slightly higher than Louisiana's cost of production, and below the costs of production for Florida and Hawaii. This price was deflated by the Producer Price Index to provide cost of production estimates for 1974–1980. Comparison of the support price scenario with the free trade (actual) scenario provides the mean annual additional cost borne by consumers to sustain the program of price supports for the period 1974–1981. This amounts to an additional cost of $4.77 per capita annually.

The own-price and income elasticities are highly inelastic. This indicates that sugar purchases are a very small percentage of consumer expenditures and consumers would continue to purchase approximately the same quantity under the indicated price increases resulting from the superimposed support program.

Whereas the consumption of sugar has declined, the overall consumption of sweeteners has remained constant. The increase in the consumption of corn sweeteners has become more pronounced since their adoption by industrial users.

SUGAR SUPPLY FUNCTIONS

Introduction

Acreage response to price changes for the period 1955–1981 is determined for both the free market and the price support scenarios for U.S. sugar production in total, individual cane-producing states, and all beet states combined. The additional years of 1955–1973 were added to the 1974–1981 study period to provide an adequate number of observations. The linear and double logarithm functions use binary variables and provide price elasticities of acreage response in the short run and long run. To reflect the free market period of 1974–1981, binary variable *Z* (retail price) is introduced with *Z* equal to zero in 1955–1973 and equal to one in 1974–1981. Long-run price elasticities for the double logarithm function consist of short-run elasticities divided by the coefficient of adjustment (1 − lambda).

U.S. Cane and Beet Production

Domestic sugar was produced by four cane-producing states and 17 beet-producing states during the study period. Cane sugar was produced by Florida, Hawaii, Louisiana, and Texas. Beet sugar–producing states were Arizona, California, Colorado, Idaho, Kansas, Michigan, Minnesota, Montana, Nebraska, New Mexico, North Dakota, Ohio, Oregon, Texas, Utah, Washington, and Wyoming.

Empirical Results of U.S. Supply Functions

The linear supply function for U.S. sugar production is $QSUS = 3000.8 + 158.19\ LGRET - 28.12\ FERL2 + 183.94\ T + 50.14\ ZLGRET$, where *QSUS* is the domestic supply of raw sugar, *LGRET* is the retail price lagged two price periods, *FERL2* is fertilizer price lagged two periods, *T* is technology, and *ZLGRET* is the slope differential (Table 9). The own-price elasticity of U.S. cane sugar supply for 1955–1974 is 0.48.

The double logarithm function for U.S. sugar is $LNQSUS = 3.8664 + .4907\ LNQSLAG + .1636\ LNRETLG - .1224\ LNFERL2 - .1527\ LNPWAGE + .2667\ LT - .0157\ ZLRETLG$, where *LN* is the natural log of the dependent and independent variables, *LNQSLAG* is the dependent variable (quantity supplied) lagged one period, *LNPWAGE* is the wage rate lagged two periods, and other variables are the same as those for the linear function (Table 10). The coefficient of adjustment of supply and expected price is .50924 (1.0 − .49076 *LNQSLAG* or lambda). The coefficient in the partial adjustment model with 21 degrees of freedom is highly significant at the 5 percent probability level. Since the *t*-ratios of *LNFERL2* and *ZLRETLG* are low, they are considered not to be significantly different from zero at the 5 percent probability level. The own-price elasticities in the short run and long run are 0.16 and 0.32, respectively. The long-run elasticity, 0.32, is equal to 0.16365 divided by 0.50924, the coefficient of adjustment.

Empirical Results of Florida Supply Function

The linear supply function for Florida is $QSFA = 895{,}270 + 83{,}042\ LGRET + 30{,}821\ T + 1{,}077{,}700\ Z - 81{,}865\ ZLGRET$, where *QSFA* is the supply of Florida raw sugar in short tons, *LGRET* is the retail price lagged two periods, *T* is technology, *Z* is the intercept differential, and *ZLGRET* is the slope differential

Table 9. Quantity of Raw Sugar Produced, Retail Price, Fertilizer Price, Trend, United States, 1955-1981

Variable	Linear Function
Dependent	QSUS
LGRET	158.19
Asymptotic T-Ratio	3.515 a/
FERL2	-28.12
Asymptotic T-Ratio	- 2.865 a/
Trend	183.94
Asymptotic T-Ratio	6.196 a/
ZLGRET	-50.14
Asymptotic T-Ratio	- 1.924 a/
Constant	3,000.80
Asymptotic T-Ratio	4.522
Durbin-Watson	1.7732 b/
Short-run Supply Elasticity	0.4806 c/

a/ 5 percent level of significance

b/ Zero autocorrelation at the 5 percent level

c/ The low elasticity is indicative of the large area dedicated to the production of sugarcane and sugarbeets in those areas where there may be limited crop alternatives.

Table 10. Partial Adjustment Model: Quantity of Raw Sugar Produced, Retail Price, Lagged Dependent Variable, Fertilizer Price, Trend, Wages, United States, 1955-1981

Variable	Double Logarithm
Dependent	LNQSUS
LNQSLAG	0.49076
Asymptotic T-Ratio	3.2960 a/
LNRETLG	0.16365
Asymptotic T-Ratio	1.2598
LNFERL2	-0.12245
Asymptotic T-Ratio	-1.4677
LNPWAGE	-0.15279
Asymptotic T-Ratio	-2.1935
LT (trend)	0.2667
Asymptotic T-Ratio	2.9083 a/
ZLRETLG	-0.0157
Asymptotic T-Ratio	-0.7587
Constant	3.8664
Asymptotic T-Ratio	3.4069
Durbin's h statistic	-0.26432 b/
Short-Run Elasticity	0.16365
Long-Run Elasticity	0.32136

a/ 5 percent level of significance

b/ Zero autocorrelation at the 5 percent level

Table 11. Quantity of Raw Sugar Produced: Linear Function, Florida, Hawaii, Louisiana, and Texas, 1955-1981

Variable	Florida	Hawaii	Louisiana	Texas c/
Dependent	QSFA	QSHI	QSLA	QSTX
LGRET	83,042	14,932	17,454	3,361.5
T-Ratio	1.9852	3.7445 a/	2.4555 a/	4.481 a/
FERL2		- 2,529		
T-Ratio		- 3.5904 a/		
FERT				457.70
T-Ratio				2.585 a/
WAGLA			-168,350	
T-Ratio			- 3.0135 a/	
TREND	30,821	10,725	18,673	
T-Ratio	4.0704 a/	2.3613 a/	4.2223 a/	
Z	1,077,700			
T-Ratio	1.8226			
ZLGRET	81,865	-10,317	- 8,226	
T-Ratio	1.9620	- 3.2559 a/	- 1.7218	
Intercept/Constant	859,270	958,899	296,180	69,029.0
T-Ratio	1.937	17.456	3.3004	4.107
R-Square	.9183			
Durbin-Watson	1.7823 b/	1.971 b/	2.0025	2.071 b/
Own-Price Elasticity	2.249	0.19516	0.5140	1.020

a/ 5 percent level of significance

b/ Zero autocorrelation at the 5 percent level

c/ 1974-1981

(Table 11). The own-price elasticity for 1955–1973 is 2.25.

The double logarithm supply result is $LQSFA = 1.2434 + .6073\ LQSFAL + 1.2774\ LLGRET + .3075\ LT + 3.208\ Z - 1.2351\ ZLLGRET - .13626\ LWAGFL$ (Table 12), where L is the natural logarithm of the variable, $LQSFAL$ is the lagged dependent variable, $LWAGFL$ is the wage rate for Florida lagged two periods, and other variables are similar to those for the linear equation. The significance of the coefficients is indicated by their respective t-ratios, which are significantly different from zero, except for $LWAGFL$, at the 5 percent level. The own-price elasticities in the short run and long run are 1.28 and 3.25, respectively (Table 12).

Empirical Results of Hawaii Supply Function

The linear supply function for Hawaii is $QSHI = 958{,}899 + 14{,}932\ LGRET - 2529\ FERL2 + 10{,}725\ T - 10{,}317\ ZLGRET$, where $QSHI$ is the domestic supply in tons of raw sugar, $LGRET$ is the retail price lagged four periods, $FERL2$ is the fertilizer price lagged three periods, T is technology, and $ZLGRET$ is the slope differential (Table 11). The own-price elasticity for 1955–1973 is 0.20.

The double logarithm supply result is $LQSHI = 9.4561 + .31236\ LQSHILG + .13214\ LGRETALG - .0840\ LFERL2 + .0560\ LT - .04773\ ZLGRETAL$, where L is the natural logarithm of the variables, $LQSHILG$ is the lagged dependent variable, and other variables are similar to those for the linear form (Table 12). The coefficient of $LQSHILG$ is equal to one minus lambda, solving for lambda, which provides the coefficient of adjustment for determining long-run elasticities. The significance of the coefficients is indicated by their respective t-ratios, which are significantly different from zero, except for technology, at the 5 percent probability level. The own-price elasticities in the short run and long run are 0.13 and 0.19, respectively. The long-run elasticity, 0.19, is equal to 0.1321 divided by the adjustment coefficient of 0.6876.

Empirical Results of Louisiana Supply Function

The linear supply result in tons of raw sugar produced in Louisiana is $QSLA = 296{,}180 + 17{,}454\ LGRET - 168{,}350\ WAGLA + 18{,}673\ T + 8226\ ZLGRET$, where $QSLA$ is the Louisiana supply of raw sugar, $LGRET$ is the retail price lagged two periods, T is technology, and $ZLGRET$ is the slope differential (Table 11). The own-price elasticity for 1955–1973 is 0.51.

The double logarithm supply result is $LQSLA = 4.374 + .5880\ LQSLAL + .4287\ LLGRET - .0966\ ZLLGRET$, where L is the natural logarithm of the variables, $LQSLAL$ is the lagged dependent variable, and other variables are the same as for the linear function (Table 12). The coefficient of $LQSLAL$ is equal to one minus lambda, which provides a coefficient of adjustment that is used in determining long-run elasticities. The significance of the coefficients is indicated by their respective t-ratios, which are significantly different from zero at the 5 percent probability level. The own-price elasticities in the short run and long run are 0.43 and 1.04, respectively.

Empirical Results of Texas Supply Function

The linear supply result for Texas in tons of raw sugar is $QSTX = 69{,}029 + 3361.5\ LGRET - 457.7\ FERT$, where $QSTX$ is the domestic supply of raw sugar in Texas, and $FERT$ is price of fertilizer lagged one period (Table 11). The short-run own-price

Table 12. Quantity of Raw Sugar Produced: Partial Adjustment Model, Florida, Hawaii, Louisiana, and Texas, 1955-1981

Variable	Florida	Hawaii	Louisiana	Texas c/
Dependent	LQSFA	LQSHI	LQSLA	LQSTX
LQSL	0.6073	0.31236	0.58795	-0.04526
T-Ratio	4.2203 a/	2.1580	4.2163 a/	-4.4553 a/
LGRETL	1.2774	0.13214	0.42870	0.86120
T-Ratio	1.6092	5.1535 a/	2.4047 a/	7.16480 a/
LFERL		-0.0840		
T-Ratio		-5.6549 a/		
LT	0.30759	0.0560		
T-Ratio	1.7833	1.2129		
Z	3.2089 a/			
T-Ratio	1.5419			
ZLGRET	-1.2351	-0.047738	-0.09657	
T-Ratio	-1.5509	-3.9832 a/	-2.1621	
LWAGL2	-0.13626			
T-Ratio	-0.97598			
Constant	1.2434	9.4561	4.3738	9.0482
T-Ratio	0.57791	4.7888	2.5178	25.747
R-Square		0.8312		
Durbin's h statistic	-0.4085 b/	-0.6437	-0.58925 b/	-0.9040 b/
Short-run own-price elasticity	1.277	0.1321	0.429	0.861
Long-run own-price elasticity	3.252	0.1922	1.040	

a/ 5 percent level of significance

b/ Zero autocorrelation at the 5 percent level

c/ 1974-1981

elasticity for the period 1974-1981 for the linear form is 1.02.

The double logarithm supply result for Texas for the 1974-1981 period is *LQSTX* = 9.0482 − 0.04526 *LQSTXL* + 0.86120 *LLCRET,* where *L* is the natural logarithm of the variables, *LQSTXL* is the lagged dependent variable, and *LLCRET* is the retail price lagged two periods (Table 12). The short-run elasticity for the double logarithm function is 0.86. The long-run elasticity was not determined for Texas because the eight observations were considered inadequate to estimate the supply function for the period 1955-1981. Thus the analysis was limited to the 1974-1981 period.

Comparative Elasticities

All forms of supply elasticities are highest for Florida and lowest for Hawaii. Hawaii has very limited potentials for alternative crops on sugar lands. Supply response is also affected by the length of harvest between crops and length of stand.

Acreage Response Under Price Support Program

The purpose of this section is to determine the probable acreage response during the period of 1974-1981 under the superimposed price support program. The estimation of acreage planted for Hawaii and the beet-producing states approximates the intentions of farmers under an administered price situation. Due to the lack of data on acreage planted, acreage harvested was used as a proxy for Florida and Louisiana. Texas was excluded from the analysis because data for 1955-1973 were not obtainable and the 1974-1981 period did not provide enough observations. To reflect the free market period of 1974-1981, binary variables are introduced with *Z* equal to zero in 1955-1973, and equal to one in 1974-1981. If the estimated coefficient of *Z* is statistically significant, it provides insight into the change in intercept during this period. Similarly, if *Z* multiplied by price is statistically significant, it provides insight into the change in slope during the period.

To determine the change in acreage during the period 1974-1981, previously estimated acreage response equations are used to calculate the predicted acreage under the support program. The results are compared with the predicted acreage under the free market period scenario. The estimated coefficients derived from regression for the period 1955-1981 are used to predict the acreage response under the modeled support program.

Empirical Results of Florida Acreage Response

The acreage response regression for all sugar-producing areas was estimated by using Ordinary Least Squares and tested for the presence of autocorrelation. The Florida regression was estimated over the time period of 1955-1981 using the following variables: (1) acreage harvested, (2) lagged acreage harvested, (3) lagged prices, (4) time trend, and (5) binary variables. Since autocorrelation was detected, the equation was reestimated using an autoregressive model, the Cochrane-Orcutt procedure.

Variables for both the linear and double logarithm equations are quantified in Table 13. In spite of autocorrelation, the linear equation is useful for comparing acreage response elasticities with those obtained in the double logarithm partial adjustment model.

The coefficient of adjustment obtained from the linear equation is 0.6844 (1.0 − 0.3156), and that for the double logarithm equation is 0.4223 (1.0 − 0.5777).

Table 13. Partial Adjustment Model: Acreage Harvested, Lagged Acreage, Price of Sugar, Trend, Florida, 1955-1981

Variable	Linear Function	Double Logarithm
Dependent	FLACHAR	FLACHAR
FLHARLG1	0.3156	0.5777
Asymptotic T-Ratio	1.5665	2.2552 a/
PR1	1,544,000	1.3944
Asymptotic T-Ratio	4.4704 a/	2.4385 a/
TREND	10,450	0.0556
Asymptotic T-Ratio	3.9133 a/	1.7642
Z	179,690	-2.9370
Asymptotic T-Ratio	3.6749 a/	-2.4244 a/
ZPR1	-1,457,500	-1.3438
Asymptotic T-Ratio	4.1483 a/	-2.3007 a/
Constant	- 232,550	7.0727
Asymptotic T-Ratio	- 4.2963	2.2834
Durbin's h statistic	Cannot be Computed	Cannot be Computed
Short-run elasticity	1.2430	1.3944
Long-run elasticity		3.3020

a/ 5 percent level of significance

These coefficients indicate the degree of adjustment of acreage harvested in response to own-price expectations and previous period price. As the coefficient of adjustment approaches one, it indicates that the expected price closely approximates the price in the previous period. The calculated coefficients of adjustment in the linear and double logarithm equations indicate that Florida cane farmers adjust their acreage harvested only moderately in response to price expectations.

The elasticity of acreage harvested expressed at the means, with respect to lagged prices, is 1.24 for the linear model. When the coefficients are expressed as elasticities in the double logarithm function, the short-run elasticity is 1.39 and the long-run elasticity is 3.30 (1.3944 divided by 0.4223, the coefficient of adjustment). The elasticity of acreage harvested with respect to lagged price is thus highly elastic.

Given the acreage analysis under the partial adjustment model for harvested sugarcane acreage for Florida under actual conditions, sugarcane acreage was estimated for the period 1974-1981 for the price support scenario. Prices were related

Table 14. Estimated Acreage Differential Under a Free Market and Price Support Program, Florida, 1974-1981

Estimated Equation: Harvested Acreage Response

FLACHAR = 7.0727 + .57769 FLHARLG1 = 1.3944 PR1 + .05565 T - 2.9370 Z - 1.3438 ZPR1

Year	Observed Values Natural Logarithm	Estimated Acreage Free Market	Estimated Acreage Price Support	Estimated Acreage Differential	Observed Values Natural Antilogarithm	Estimated Acreage Free Market	Estimated Acreage Price Support	Estimated Acreage Differential
1974	12.462	12.353	12.347	- 0.006	258,331	231,654	230,268	- 1,385
1975	12.566	12.498	12.498	-0-	286,645	267,801	267,801	-0-
1976	12.564	12.595	12.595	-0-	286,072	295,801	295,079	-0-
1977	12.560	12.580	12.591	0.011	284,930	290,686	293,902	3,215
1978	12.589	12.608	12.643	0.035	295,966	298,941	309,588	10,648
1979	12.660	12.688	12.719	0.031	314,897	323,838	334,035	10,196
1980	12.730	12.771	12.813	0.042	337,729	351,864	366,957	15,093
1981	12.760	12.892	12.892	-0-	348,015	397,122	397,122	-0-

to the weighted cost of production plus transportation charges, deflated by the Index of Prices Paid by Farmers. In order to estimate the acreage response for the 1974–1981 support scenario, support prices were substituted for free market prices in the double logarithm equation:

$$\begin{aligned} FLACHAR_{74} &= 7.0727 - .5777\ FLHARLG1 + 1.3944\ PR1 + .055654\ T - 2.9370\ Z - 1.3438\ ZPR1 \\ &= 7.0727 + .5777(12.457) + 1.3944(-1.9305) + .055654(20) - 2.9370(1) - 1.3438(-1.9305) \\ &= 12.353 \end{aligned}$$

where $FLACHAR$ = harvested acreage, $FLHARLEG1$ = harvested acreage lagged one period, $PR1$ = price of sugar lagged one period, T = trend (1974 = year 20), Z = binary variable, and $ZPR1$ = price of sugar lagged one period × Z (Table 13).

For the price support scenario, $FLACHAR_{74}$ = antilog$_e$ 12.347 = 230,268 (Table 14). The same procedure was used to estimate acreage response for the subsequent periods. The only change would be prices inherent in the support program. Free market prices for 1974, 1975, and 1980 exceeded programmed support prices, thus indicating no acreage differentials between the two scenarios for those years. Common values for the two scenarios appear during 1975, 1976, and 1981 because of the one-year lag in supply response. The estimated acreage-harvested differentials under the free market and the administered price support program as shown in Table 14 indicate that Florida is highly responsive to changes in lagged prices.

The relatively high elasticities of acreage response with respect to lagged price in the short and long run of 1.39 and 3.30, respectively (Table 13), and the coefficient of adjustment of .42231 indicate consistency with the above conclusion. Based on the analysis, farmers would increase acreage in the long run approximately 3.30 percent for a corresponding lagged price increase of 1 percent. The coefficient of adjustment indicates that Florida sugarcane producers adjust their acreage and price expectations substantially from year to year in relation to the magnitude of change in the actual lagged price. Estimated acreage under the price support scenario compared to free market conditions did not differ substantially (Table 14).

Empirical Results of Hawaii Acreage Response

The Hawaii acreage response equation is similar to that for Florida, except that the dependent variable is acreage planted rather than acreage harvested. The equation was tested for the presence of first-order autocorrelation between the residual terms. Since the Durbin's h statistic was greater than 1.645, the hypothesis of zero autocorrelation at the 5 percent probability level can be rejected (Johnston, 1972, p. 313). The equation was subsequently estimated under an autoregressive model, the Cochrane-Orcutt process, which provides asymptotic estimates over the period 1955–1981. The variables in the equation are (1) planted acreage, (2) planted acreage lag, (3) price of sugar lagged two periods, and (4) time trend. The time trend was included to account for technology and omitted other variables due to unavailable data. Variables for both the linear and double logarithm equations are quantified in Table 15.

Table 15. Linear and Partial Adjustment Models: Acreage Planted, Lagged Acreage, Price of Sugar, Trend, Hawaii, 1955-1981

Variable	Linear Function a/	Double Logarithm
Dependent	LHPLTAC	LHPLTAC
HIPLTLG	0.8981	0.8988
Asymptotic T-Ratio	5.9733 b/	6.5532 a/
PR2	10,460	0.0089
Asymptotic T-Ratio	1.6413	1.7769
TREND	- 158.71	-0.00066
Asymptotic T-Ratio	- 1.6787	1.6560
Constant	23,816	1.2745
Asymptotic T-Ratio	0.6930	0.7539
Durbin's h statistic	0.89176 c/	0.7114 c/
Short-run elasticity	0.0065	0.0090
Long-run elasticity		0.0887

a/ LHPLTAC = 23,816 + 0.8981 HIPLTLG, 10,460 PR2 - 158.71, where LHPLTAC = acreage planted, HIPLTLG = lagged acreage, PR2 = price of sugar lagged two periods.

b/ 5 percent level of significance

c/ Zero autocorrelation at the 5 percent level

The coefficient of adjustment obtained from the linear equation is 0.1019 (1.0 − 0.8981), and that for the double logarithm equation is 0.1011 (1.0 − 0.89883). The equation indicates an extremely low coefficient of adjustment in relation to changes in prices. The prices are expected prices perceived by the farmer to prevail two years from the time of the current harvest. Since there are limited alternative agricultural uses for prime sugarcane lands in Hawaii at equal or greater intensity, farmers are compelled to continue to grow sugarcane as long as sugar appears viable in the long run or until viable alternative crops are discovered. The elasticity of acreage response in the linear equation is 0.0065, expressed at the means (Table 15). When the elasticities are expressed in coefficients in the double logarithm function, the short-run elasticity is 0.0090 and the long-run elasticity is 0.0887. In both instances, the elasticity of acreage planted with respect to lagged prices is highly inelastic. In order to estimate the acreage response for the 1974–1981 support scenario, support prices were substituted for free market prices in the double logarithm equation:

$$
\begin{aligned}
LHPLTAC_{74} &= 1.2745 \\
&\quad + .8988\ HIPLTLG \\
&\quad + .00898\ PR2 \\
&\quad - .00066\ T \\
&= 1.2745 \\
&\quad + .8988\ (12.331) \\
&\quad + .00898\ (-1.9188) \\
&\quad - .00066\ (20) \\
&= 12.327 \text{ for the price support scenario (Table 16)} \\
LHPLTAC_{74} &= \text{antilog}_e\ 12.327 \\
&= 225{,}708 \text{ (Table 16)}
\end{aligned}
$$

This procedure was used to estimate acreage response for the subsequent periods. The free market price exceeded the support price in 1974, 1975, and 1980, thus the free market price for these years was used for both scenarios. However, because of a two-year lag in supply response, the common years are 1976, 1977, and 1982, with the latter exceeding the study period. The estimated acreage-planted differential under a free market as compared with an administered price support program is extremely small, thus further supporting the findings that Hawaii sugarcane is almost nonresponsive to changes in lagged prices (Table 16).

Empirical Results of Louisiana Acreage Response

The variables included in the Louisiana acreage equation are (1) acreage harvested, (2) lagged acreage harvested, (3) lagged price, (4) trend, and (5) binary variables. Variables for the linear and double logarithm equations are quantified in Table 17. Since the Durbin's h statistic was greater than 1.645, the hypothesis of zero autocorrelation at the 5 percent probability level for Louisiana acreage response was rejected. The equation was subsequently estimated under the Cochrane-Orcutt process, which provides asymptotic estimates of the equation over the period 1955-1981.

The coefficients of adjustment of 0.3847 (1.0 − 0.6153) for the linear equation and 0.3711 (1.0 − 0.6289) for the double logarithm equation indicate moderately low changes in acreage harvested in relation to price expectations (Table 17).

The elasticity of acreage harvested with respect to lagged prices in the linear equation at the means is 0.07. When the elasticities are expressed as coefficients in the double logarithm function, the short-run elasticity is 0.09 and the long-run elasticity is 0.26, thus indicating that the elasticity of acreage harvested with respect to lagged prices is highly inelastic in the short run and moderately inelastic in the long run.

In order to estimate the acreage response for the 1974-1981 support scenario, support prices were substituted for free market prices in the double logarithm equation (Table 18):

$$
\begin{aligned}
\mathrm{LACHAR}_{74} &= 4.7739 \\
&\quad + .62891\ LAHARLG1 \\
&\quad + .097692\ PR1 \\
&\quad + .0006477\ T \\
&\quad - .1040\ Z \\
&= 4.7739 \\
&\quad + .62891(12.673) \\
&\quad + .097692(-\ 1.9305) \\
&\quad + .0006477(20) \\
&\quad - .1040(1) \\
&= 12.5810 \\
LACHAR_{74} &= \text{antilog}_e\ 12.5810 \\
&= 290{,}977
\end{aligned}
$$

The inherent changes would be harvested acreage lagged one period, price, and time trend 20 . . . 27 (1974-1981, where 1955 = year 1). The estimated acreage-harvested differentials under a free market and administered price support program indicate that harvested acreage in

Table 16. Estimated Acreage Differential Under a Free Market and Price Support Program, Hawaii, 1974-1981

Estimated Equation: Planted Acreage Response

LHPLTAC = 1.2745 + 0.8988 HIPLTLG + 0.0089077 PR2 - 0.00066 T

Year	Observed Values Natural Logarithm	Estimated Acreage Free Market	Estimated Acreage Price Support	Estimated Acreage Differential	Observed Values Natural Antilogarithm	Estimated Acreage Free Market	Estimated Acreage Price Support	Estimated Acreage Differential
1974	12.320	12.320	12.327	0.007	224,134	224,134	225,708	1,574
1975	12.308	12.312	12.317	0.005	221,460	222,348	223,463	1,115
1976	12.308	12.307	12.307	-0-	221,460	221,239	221,239	-0-
1977	12.305	12.306	12.306	-0-	226,499	221,018	221,018	-0-
1978	12.305	12.297	12.304	0.007	220,797	219,037	220,577	1,539
1979	12.296	12.300	12.302	0.002	218,818	219,695	220,136	440
1980	12.291	12.288	12.294	0.006	217,727	217,675	218,382	1,037
1981	12.283	12.285	12.289	0.004	215,992	216,425	217,243	868

Table 17. Partial Adjustment Model, Linear and Double Logarithm Functions: Acreage Harvested, Lagged Acreage, Price of Sugar, Trend, Louisiana, 1955-1981

Variable	Linear Function	Double Logarithm
Dependent	LACHAR	LACHAR
LAHARLG1	0.6153	0.6289
Asymptotic T-Ratio	3.2058 a/	3.5180 a/
PR1	133,020	0.0976
Asymptotic T-Ratio	1.3710	1.4551
TREND	1,754.5	0.0064
Asymptotic T-Ratio	1.6189	1.6229
Z	-29,745	-0.1040
Asymptotic T-Ratio	- 1.9585	-1.9103
Constant	70,034	4.7739
Asymptotic T-Ratio	1.6202	2.1224
Durbin's h statistic	- 0.32234 b/	-0.1911 b/
Short-run elasticity	0.0735	0.0977
Long-run elasticity		0.2635

a/ 5 percent level of significance

b/ Zero autocorrelation at the 5 percent level

Louisiana is responsive to changes in lagged prices. This acreage response is somewhat inconsistent with the lower elasticity of acreage response for the longer 1955-1981 period. This probably can be explained through a recent change in sugarcane production in Louisiana. Angelo and Hoff (1983) note that Louisiana has recently emerged as a major producer of sugarcane with record high yields, resulting in an increase in raw sugar production and the lowest cost of production of the sugarcane states. The moderately low coefficient of adjustment indicates that sugarcane producers adjust their acreage and price expectations moderately from year to year in relation to the magnitude of changes in the actual lagged price. In this instance, producers rely on acreage harvested during the previous period and lagged prices to facilitate their decision to harvest in the current period. In light of the recent trends in increased yield, Louisiana has responded rather strongly to changes in prices (Table 18).

Empirical Results of Sugarbeet Acreage Response

The Durbin's *h* statistic for the sugarbeet acreage response equation was greater than

Table 18. Estimated Acreage Differential Under a Free Market and Price Support Program, Louisiana, 1974-1981

Estimated Equation: Harvested Acreage Response

LACHAR = 4.7739 + 0.62891 LAHARLG1 + 0.097692 PR1 + 0.0064774 T - 0.10400 Z

Year	Observed Value Natural Logarithm	Estimated Acreage Free Market	Estimated Acreage Price Support	Estimated Acreage Differential	Observed Value Natural Antilogarithm	Estimated Acreage Free Market	Estimated Acreage Price Support	Estimated Acreage Differential
1974	12.638	12.565	12.581	0.016	308,045	286,359	290,977	4,619
1975	12.638	12.637	12.637	-0-	308,045	307,737	307,737	-0-
1976	12.581	12.621	12.621	-0-	290,977	302,852	302,852	-0-
1977	12.625	12.539	12.572	0.033	304,066	279,009	288,370	9,361
1978	12.535	12.531	12.602	0.071	277,895	276,786	297,152	20,336
1979	12.401	12.502	12.554	0.052	243,045	268,875	283,226	14,351
1980	12.445	12.435	12.461	0.026	253,977	251,450	258,074	6,623
1981	12.487	12.512	12.512	-0-	264,871	271,577	271,577	-0-

1.645. Thus the hypothesis of zero autocorrelation at the 5 percent probability level was rejected and the equation was estimated under the Cochrane-Orcutt process over the period 1955–1981. The variables included in the equation are (1) acreage planted and harvested, (2) lagged acreage planted and harvested, (3) lagged prices, (4) trend, and (5) binary variables. The coefficient of adjustment obtained from the linear acreage-planted equation is 0.525 (1.0 − 0.4747) and that from the double logarithm equation is 0.4874 (1.0 − 0.5426), as shown in Table 19. The coefficient of adjustment obtained from the linear acreage-harvested equation is 0.5343 (1.0 − 0.4657) and that from the double logarithm equation is 0.4133 (1.0 − 0.5867), as shown in Table 20. The coefficients indicate moderate adjustments to expected prices for both acreage planted and acreage harvested. This may indicate some tendency to decrease beet acreage planted in response to more profitable crop alternatives.

The elasticity is 0.69 for the linear acreage-planted equation and 0.40 for the linear acreage-harvested equation. When the coefficients are expressed as elasticities in the double logarithm acreage-planted equation, the short-run elasticity is 0.68 and the long-run elasticity is 1.48 (Table 19). This indicates that acreage planted with respect to lagged price is inelastic in the short run, but elastic in the long run. For the double logarithm acreage-harvested equation, the short-run elasticity is 0.17 and the long-run elasticity is 0.41 (Table 20), inelastic in both instances.

In order to estimate the acreage response for the 1974–1981 support price scenario, support prices were substituted for free market prices in the double logarithm equation:

$$
\begin{aligned}
BEACPLT_{74} &= 7.5975 \\
&\quad + .54264\ BEACPLG \\
&\quad + .67616\ PR1 \\
&\quad + .012735\ T \\
&\quad - 1.0570\ Z \\
&\quad - .46380\ ZPR1 \\
&= 7.5975 \\
&\quad + .54264\ (14.062) \\
&\quad + .67616(-1.9305) \\
&\quad + .012735(20) \\
&\quad - 1.0570(1) \\
&\quad - .46380(-1.9305) \\
&= 14.015 \text{ (Table 21)} \\
BEACPLT_{74} &= \text{antilog}_e\ 14.015 \\
&\quad = 1{,}220{,}779 \text{ (Table 21)}
\end{aligned}
$$

This procedure was used to estimate acreage response for the subsequent period. The inherent changes would be planted acreage lagged one period, price, and time trend 20 . . . 27. The estimated acreage-planted differentials under the free market and the administered price support program indicate that beet acreage is highly sensitive to changes in price.

IMPORT RESTRICTIONS: U.S. SUGAR INDUSTRY

Introduction

The derived elasticities obtained from the linear demand and supply equations are used in this section to determine consumption and production deadweight loss, total deadweight loss, and producers' surplus in the United States that would have resulted from the superimposed price support scenario for the 1974–1981 period. Tariff revenues and foreign imports are estimated by using the *ad valorem* tariff rate and derived elasticities, respectively. The loss in consumers' surplus is expressed in dollars per capita and compared with the per capita cost of the modeled support program.

Table 19. Partial Adjustment Model: Acreage Planted, Lagged Acreage, Price of Sugar, Trend, Beet States, 1955-1981

Variable	Linear Function	Double Logarithm
Dependent	BEACPLT	BEACPLT
BEACPLG	0.4747	0.5426
T-Ratio	2.6339 a/	3.6710 a/
PR1	5,763,800	0.6761
T-Ratio	2.6026 a/	2.1542
TREND	17,706	0.01273
T-Ratio	2.1191	1.9583
Z	-4,071,800	-1.0571
T-Ratio	- 1.8353	-1.6493
ZPR1		-0.4638
T-Ratio		-1.4678
Constant	- 358,260	
T-Ratio	- 1.0683	
Intercept		7.5975
T-Ratio		3.4166
R-Square		0.8391
Durbin's h statistic	0.0977 b/	-0.0207 b/
Short-run elasticity	0.6948	0.6762
Long-run elasticity		1.4784

a/ 5 percent level of significance

b/ Zero autocorrelation at the 5 percent level

Table 20. Partial Adjustment Model: Acreage Harvested, Lagged Acreage, Price of Sugar, Trend, Beet States, 1955-1981

Variable	Linear Function	Double Logarithm
Dependent	BEACHAR	BEACHAR
BEHARLG1	0.4657	0.5866
T-Ratio	3.1363 a/	3.9429 a/
PR1	3,180,500	0.1679
T-Ratio	3.5632 a/	2.3447 a/
TREND	16,504	0.0084
T-Ratio	2.2929	1.3827
ZPR1	-1,493,700	0.0498
T-Ratio	- 2.3437 a/	1.2954
Intercept	6,418.7	6.0195
T-Ratio	0.0442	2.9796
R-Square	0.8102	0.8158
Durbin's h statistic	0.1960 b/	-0.0136 b/
Short-run elasticity	0.4018	0.1679
Long-run elasticity		0.4062

a/ 5 percent level of significance

b/ Zero autocorrelation at the 5 percent level

Basic Scenario Assumptions

Specifications for the basic model for assessing the welfare effects of the imposed tariff are

(1) The domestic sugar industry is perfectly competitive.

(2) The cost of transportation is zero.

(3) The study does not address the secondary effects of other industries.

(4) The tariffs imposed in the scenarios are static in the short run.

(5) The elasticities used in the determination of the welfare effects are short run.

The imposition of a specific duty and an *ad valorem* tariff rate is examined to determine the reduction in consumers' surplus as a consequence of redistribution of benefits to producers and government. There is a portion of the consumers' surplus that is considered total deadweight loss to society. This deadweight loss results from inefficiency in production and inequities in not allowing consumers to purchase sugar at the free market price. The specific duty and *ad valorem* tariff rates used in this analysis prevailed in 1981. The duty rate

Table 21. Estimated Acreage Differential Under a Free Market and Price Support Program, Beet States, 1974-1981

Estimated Equation: Planted Acreage Response

BEACPLT = 7.5975 + 0.54264 BEACPIG + 0.67616 PR1 + 0.012735 T - 1.0570 Z - 0.46380 ZPR1

Year	Observed Values Natural Logarithm	Estimated Acreage Free Market	Estimated Acreage Price Support	Estimated Acreage Differential	Observed Values Natural Antilogarithm	Estimated Acreage Free Market	Estimated Acreage Price Support	Estimated Acreage Differential
1974	14.040	13.988	14.015	0.027	1,251,684	1,188,259	1,220,779	32,520
1975	14.282	14.192	14.192	-0-	1,594,387	1,457,160	1,457,160	-0-
1976	14.238	14.265	14.265	-0-	1,525,755	1,567,512	1,567,512	-0-
1977	14.057	14.131	14.214	0.083	1,273,144	1,370,930	1,489,573	118,642
1978	14.082	13.991	14.119	0.128	1,303,374	1,191,829	1,354,577	162,748
1979	13.969	14.035	14.150	0.115	1,165,896	1,246,064	1,397,227	151,163
1980	14.024	13.983	14.101	0.118	1,231,816	1,182,333	1,330,413	148,081
1981	14.045	14.154	14.154	-0-	1,257,958	1,402,827	1,402,827	-0-

assessed per pound of imported raw sugar in 1981 was $0.01875. The duty is specified as follows: raw sugar, 100 degrees at $0.019875 minus $0.000281 for each degree below 100 degrees, and a minimum of $0.012844. Since the majority of the raw sugar imported is 96 degrees, a duty rate adjustment was necessary. The 1981 *ad valorem* tariff rate for sugars, syrups, and molasses was 20 percent. These two tariff rates are used in this analysis to determine the probable reduction in consumers' surplus resulting from the imposition of a tariff. These rates represent the extreme points of a continuum of imposed tariffs on foreign imported sugar.

In general, the imposition of a tariff in either a duty or *ad valorem* context creates a price differential between the free market price and the free market price plus the specific tariff. The price differential has the following impact:

(1) Expansion of domestic production in direct response to the increase in price to the producer.

(2) Expansion of production resources for higher productivity of employees.

(3) Reduction in the consumption of sugar as a consequence of the increase in retail price.

(4) Reduction in consumers' surplus as a consequence of the increase in retail price.

(5) Reduction in imports as a consequence of the increased domestic production and decreased consumption.

(6) Increase in government revenues as a result of the duty.

(7) Increase in producers' surplus resulting from a redistribution from consumers' surplus.

Partial Equilibrium Model

The determinations of welfare effects are formulated to estimate producers' and consumers' surplus, production and consumption deadweight loss, and tariff revenues. The procedures of Magee (1972) and Morkre and Tarr (1980) are used to determine the approximate welfare effects of a tariff. Gross estimates of welfare gains and losses are premised on linear demand and supply curves and their respective elasticities. The derived elasticity from the partial adjustment model is substituted in the static formulas to determine the magnitude of welfare effects. Since the price elasticities are short term, they may tend to understate the magnitude of the welfare loss. The long-run elasticities are generally greater in magnitude than the short-run elasticities, thus indicating that the potential welfare losses are greater in a growth context. The own-price elasticities of the supply and demand functions are used to determine the welfare effects under a partial equilibrium model. If the elasticities are inelastic, it is reasonable to conclude that the estimated welfare effect will be small and the reverse if they are elastic.

Consumption Deadweight Loss

The consumption deadweight loss for the 1974–1981 period was determined as follows:

$$DLWC = .5\, t^2\, D\, e_d \qquad (1)$$

where $DWLC$ = the annual deadweight loss for consumption inequities, $t = (t_a / 1 + t_a)$ representing the change in retail price as a result of an imposed tariff, D = total value of quantity demanded at the retail price, and e_d = the own-price elasticity of demand.

To determine the $DWLC$ for the imposed duty of $0.01875 for 1974, appropriate values are substituted in formula (1):

$$\begin{aligned} DWLC &= .5\,(.05799/1.05799)^2 \\ &\quad \times (\$7{,}420{,}252{,}000) \\ &\quad \times (-0.07463) \\ &= -\$832{,}000 \text{ (Table 22)} \end{aligned}$$

Table 22. Annual Deadweight Loss Incurred from the Imposition of the 1.875 Cent Duty and 20 Percent *Ad Valorem* Tariff Rate on Sugar, 1974-1981

$0.01875 Duty Rate a/

Year	DWLC b/	DWLP c/	DWLT d/
		(1000 dollars)	
1974	- 832	- 2,784	- 3,616
1975	- 649	- 2,719	- 3,366
1976	-1,045	- 4,323	- 5,368
1977	-1,173	- 4,216	- 5,389
1978	-1,055	- 3,557	- 4,612
1979	- 766	- 3,526	- 4,292
1980	- 584	- 2,153	- 2,737
1981	- 593	- 2,449	- 3,042
Annual Average	- 837	- 3,216	- 4,053

20 Percent *Ad Valorem* Tariff Rate a/

Year	DWLC b/	DWLP c/	DWLT d/
		(1000 dollars)	
1974	7,690	25,744	33,434
1975	7,853	32,853	40,706
1976	5,513	22,804	28,317
1977	5,117	18,391	23,508
1978	5,440	18,341	23,781
1979	5,667	19,941	25,608
1980	9,202	33,872	43,074
1981	8,231	33,950	42,181
Annual Average	6,839	25,737	32,576

a/ Tariff Schedule of the U.S. International Trade Commission, 1981
b/ Consumption deadweight loss
c/ Production deadweight loss
d/ Total deadweight loss, production and consumption

Table 23. Static Determination of Welfare Losses and Gains with the Imposition of a 1.875 Cent Duty on Imported Sugar, United States, 1974-1981

	1974	1975	1976	1977
	(thousands of dollars)			
DWLC[a]	$ 832	$ 649	$ 1,045	$ 1,173
DWLP[b]	2,784	2,719	4,323	4,216
DWLT[c]	3,616	3,366	5,368	5,389
PS	208,625	233,281	243,624	215,680
TR	206,630	133,700	148,894	215,680
CS	(418,871)	(370,347)	(397,886)	(391,818)

	1978	1979	1980	1981	Annual Average
DWLC[a]	$ 1,055	$ 766	$ 584	$ 593	$ 837
DWLP[b]	3,557	3,526	2,153	2,449	3,216
DWLT[c]	4,612	4,292	2,737	3,042	4,053
PS	198,132	205,853	211,123	225,282	217,699
TR	198,164	186,951	166,859	133,830	173,838
CS	(400,908)	(397,096)	(377,982)	(362,154)	(389,634)

a/ Consumption deadweight loss

b/ Production deadweight loss

c/ Total deadweight loss, production and consumption

This procedure was used for subsequent years through 1981, with changes in t and demand to facilitate the computation. Similarly, to determine the $DWLC$ for the imposed 20 percent *ad valorem* tariff for 1974 the above formula (1) was used:

$$\begin{aligned} DWLC &= .5\,(.20/1.20)^2 \\ &\quad \times (\$7{,}420{,}252{,}000) \\ &\quad \times (-0.07463) \\ &= -\ \$7{,}690{,}000 \text{ (Table 22)} \end{aligned}$$

The own-price elasticity of -0.075 in the estimated linear demand function is extracted from Table 6.

Production Deadweight Loss

The production deadweight loss was determined for the 1974-1981 period using the following formula:

$$DWLP = -.5\, t^2\, S\, e_s \qquad (2)$$

where $DWLP$ = the annual deadweight loss from production inefficiencies, $t = (t_a / 1 + t_a)$ representing the change in retail price as a result of the imposed tariff, S = total quantity supplied multiplied by retail price, and e_s = the own-price elasticity of supply.

To determine the $DWLP$ for the imposed duty of \$0.01875 for 1974 appropriate values from the partial adjustment model are substituted in formula (2):

$$\begin{aligned} DWLP &= -.5\,(.05799/1.05799)^2 \\ &\quad \times (\$3{,}857{,}059{,}800)\,(.48058) \\ &= -\$2{,}784{,}000 \text{ (Table 22)} \end{aligned}$$

This procedure was used for subsequent years through 1981, with changes in t and supply appropriate for the computation. Similarly, to determine the $DWLP$ for the imposed 20 percent *ad valorem* tariff for 1974, formula (2) was used:

$$\begin{aligned} DWLP &= -.5\,(.20/1.20)^2 \\ &\quad \times (\$3{,}857{,}059{,}800)\,(.4806) \\ &= -\ \$25{,}744{,}000 \text{ (Table 22)} \end{aligned}$$

The own-price elasticity of 0.48 in the estimated linear supply function is extracted from Table 9.

Producers' Surplus

The producers' surplus was determined for the period 1974–1981 using the following formula:

$$PS = t\,S\,(1 - .5\,t\,e_s) \qquad (3)$$

where PS = producers' surplus = the redistribution of gain as a result of an increase in price, $t = (t_a / 1 + t_a)$ representing the change in retail price as a result of a tariff, S = quantity supplied multiplied by retail price, and e_s = own-price elasticity of domestic supply.

To determine the producers' surplus for the imposed duty of \$0.01875 for 1974, appropriate values from the partial adjustment model are substituted in formula (3):

$$\begin{aligned} PS &= (.05799/1.05799) \\ &\quad \times (\$3{,}857{,}059{,}800) \\ &\quad \times (1 - .5\,(.05799/1.05799)) \\ &= \$208{,}625{,}000 \text{ (Table 23)} \end{aligned}$$

This procedure was used for subsequent years through 1981, with changes in t and supply to facilitate the computation. Similarly, to determine the producers' surplus for an imposed 20 percent *ad valorem* tariff, formula (3) was used:

$$\begin{aligned} PS &= (.20/1.20)\,(\$3{,}857{,}059{,}800) \\ &\quad \times (-\ .5\,(.1666)\,(.48058)) \\ &= \$617{,}074{,}000 \text{ (Table 24)} \end{aligned}$$

Tariff Revenues

Tariff revenues were determined for the period 1974–1981 using the following formula:

$$TR = t\,(D - S) \qquad (4)$$

where TR = tariff revenue, t = the actual specific or *ad valorem* tariff rate, D = import quantity demanded multiplied by domestic retail price, and S = import quantity supplied multiplied by domestic retail price.

To determine the tariff revenue for an imposed duty of \$0.01875 for 1974, appropriate values from the partial adjustment model are substituted in formula (4):

$$\begin{aligned} TR &= .05799 \\ &\quad \times (\$7{,}420{,}252{,}000 - \$3{,}857{,}059{,}800) \\ &= \$206{,}630{,}000 \text{ (Table 23)} \end{aligned}$$

This procedure was used for subsequent years through 1981, with demand and supply total revenue figures to facilitate the computation. Similarly, to determine the tariff revenue for an imposed 20 percent *ad valorem* tariff, formula (4) was used:

$$\begin{aligned} TR &= .20\,(\$7{,}420{,}252{,}000 - \$3{,}857{,}059{,}800) \\ &= \$712{,}638{,}000 \text{ (Table 24)} \end{aligned}$$

Consumers' Surplus

Under the 1.875-cent-per-pound duty rate scenario, consumers' surplus reduction ranges from \$362 million in 1981 to \$419 million in 1974 (Table 23). Similarly, under the 20 percent *ad valorem* tariff rate scenario, consumers' surplus reduction ranges from \$901 million in 1977 to \$1.6 billion in 1980 (Table 24).

Table 24. Static Determination of Welfare Losses and Gains with the Imposition of an Ad Valorem Tariff Rate of 20 Percent, United States, 1974-1981

	1974	1975	1976	1977
	(thousands of dollars)			
DWLC[a/]	$ 7,690	$ 7,853	$ 5,513	$ 5,117
DWLP[b/]	25,744	32,853	22,804	18,391
DWLT[c/]	33,434	40,706	28,317	23,508
PS	617,074	787,498	546,610	440,840
TR	712,638	530,977	380,561	436,420
CS	(1,363,146)	(1,359,181)	(955,488)	(900,768)

	1978	1979	1980	1981	Annual Average
DWLC[a/]	$ 5,440	$ 5,667	$ 9,202	$ 8,231	$ 6,839
DWLP[b/]	18,341	19,941	33,872	33,950	25,737
DWLT[c/]	23,781	25,608	43,074	42,181	32,576
PS	439,634	477,990	811,906	813,802	616,919
TR	500,351	496,155	760,714	571,067	548,613
CS	(963,766)	(999,753)	(1,615,694)	(1,427,050)	(1,198,130)

a/ Consumption deadweight loss

b/ Production deadweight loss

c/ Total deadweight loss, production and consumption

Imports

The effects of tariff-imposed reductions in imports on domestic consumption and production were determined for the period 1974–1981 using the following formulas:

$$CR = t\, D\, e_d \qquad (5)$$

$$PI = t\, S\, e_s \qquad (6)$$

where CR = consumption reduction, PI = production increase, $t = (t_a / 1 + t_a)$ representing the change in retail price as a result of a tariff, D = quantity demanded multiplied by retail price, S = quantity supplied multiplied by retail price, e_d = own-price elasticity of demand, and e_s = own-price elasticity of supply.

To determine the reduction in demand as a result of a $0.01875 duty for 1974, appropriate values from the partial adjustment model are substituted in formula (5):

$$\begin{aligned} CR &= (.054811)(\$7{,}420{,}252{,}000) \\ &\quad \times (.074631) \\ &= \$30{,}353{,}000 \text{ (Table 25)} \end{aligned}$$

Using the same procedure for the 20 percent *ad valorem* tariff, the reduction in consumption for 1974 amounts to $92,260,000.

Table 25. Static Determination of the Reduction in Imports with the Imposition of a 1.875 Cent Duty and 20 Percent *Ad Valorem* Tariff Rate, 1974-1981

Year	Reduced Consumption	Increased Production	Reduced Imports
		1.875 Cent Duty (1000 dollars)	
1974	$ 30,353	$101,599	$131,952
1975	27,112	113,417	140,529
1976	28,810	119,159	147,969
1977	29,407	105,678	135,085
1978	28,756	96,928	125,684
1979	28,601	100,623	129,224
1980	27,846	102,496	130,342
1981	26,536	109,443	135,979
Annual Average	28,428	106,150	134,588
		20 Percent *Ad Valorem* Tariff Rate (1000 dollars)	
1974	$ 92,260	$308,814	$401,074
1975	94,260	394,103	488,314
1976	66,211	273,550	339,689
1977	61,392	220,618	282,010
1978	65,272	220,014	285,286
1979	67,992	239,210	307,202
1980	110,390	406,318	516,708
1981	98,748	407,267	506,015
Annual Average	82,065	411,319	390,788

To determine the increase in production as a result of a $0.01875 duty, formula (6) was used:

$$PI = (.54811)(\$3,857,059,800) \times (\$.48058) = \$101,599,000 \text{ (Table 25)}$$

This procedure was used for the 20 percent *ad valorem* tariff to determine the increase in production. In years 1974 and 1980, when prices peaked, there was a significant decline in the level of imports that carried over into subsequent years as prices declined. This carry-over was compounded by the delay in acreage response to price changes. Once prices fell, production stabilized and declined, while consumption remained constant in the intervening years.

The 1.875-cent-per-pound duty results in a reduction in consumption ranging from $26.5 million in 1981 to $30.4 million in 1974, an increase in production ranging from $97.0 million in 1978 to $119.2 million in 1976, and a decline in imports ranging from $125.7 million in 1978 to $148.0 million in 1976 (Table 25). The 20 percent *ad valorem* tariff scenario results in a reduction in consumption ranging from $61.4 million in 1977 to $110.4 million in

1980, an increase in production ranging from $220.6 million in 1977 to $407.3 million in 1981, and a decline in imports ranging from $282.0 million in 1977 to $516.7 million in 1980. Much of the decline in foreign imports can be attributed to substantial gains in domestic production in direct response to increased prices.

The per capita share of the reduction in consumers' surplus under the 1.875 cent duty rate scenario ranges from $1.57 in 1981 to $1.96 in 1974, with a mean of $1.76 (Table 26). Under the 20 percent *ad valorem* tariff rate scenario, the per capita share ranges from $4.10 in 1977 to $7.11 in 1980, with a mean of $6.08.

ECONOMIC IMPLICATIONS

Modeled Price Support Program

The primary objective of the modeled price support program is to determine in retrospect the costs of maintaining a viable domestic sugar industry during the essentially nonsupport period of 1974–1981. Returns were below costs of production during all but three years of this period. Those producers who stayed in business did so only because of large capital investments and anticipation of better prices in the future. Continuation of this lack of economic viability would undoubtedly have resulted in the eventual demise of the U.S. sugar industry.

The modeled price support program is based primarily on costs of production of sugarcane. The primary limitation of previous support programs under the parity concept was that they did not reflect changes in costs of production resulting from changes in technology. The primary vehicle for maintaining the raw sugar price at or above the support level is through the imposition of import quotas. However, nonrecourse loans are also provided with rates established at a Market Stabilization

Table 26. Per Capita Share of the Reduction in Consumers' Surplus as a Result of a 1.875 Cent Duty and a 20 Percent Ad Valorem Tariff Rate Imposition, 1974-1981

Year	$0.01875 Duty	20 Percent Ad Valorem
1974	$1.96	$6.39
1975	1.72	6.25
1976	1.83	4.39
1977	1.78	4.10
1978	1.81	4.33
1979	1.76	4.45
1980	1.66	7.11
1981	1.57	6.22
Mean Per Capita Share	1.76	6.08

Price, thus ensuring loan repayment. The Commodity Credit Corporation is assumed to provide stability in prices and income to sugarcane and sugarbeet producers at time of harvest.

If the modeled support program had been implemented in 1974–1981, the research findings indicate that it would have been an effective tool in the efficient reallocation or retention of resources for the production of sugarcane and sugarbeets. Without this program, the production behavior of producers was influenced by the extraordinarily high price of raw sugar in 1974, resulting in an increase in planted acreage. The overproduction resulted in excess supply and drastic declines in sugar prices. This triggered a reduction in production, which led to stock inventory shortages and a high price again in 1980. The findings of this study indicate that this variability in supply levels would have been less if the modeled price support program had been implemented during the 1974–1981 period.

Implications of Modeled Price Support Program for Consumers

The indicated increase in annual per capita expenditure for sugar under the support and free market scenario for 1974–1981 is $4.77, compared with a much greater loss if the sugar industry had become demised because of lack of support, with no alternative use of the factors of production. Recently, there has been a decline in sugar demand in both the industrial and nonindustrial sectors in favor of corn sweeteners, notably high-fructose corn syrup. This may imply that the price differential between the two products may narrow as the decline in sugar demand continues. With the superimposed increase in sugar prices resulting from the modeled price support program, the study indicates that decreases in quantity demanded on a per capita basis would have been minimal. Since sugar is a small percentage of the consumers' budget, consumers would continue to purchase sugar rather than substitutes for direct consumption.

Deficiency Payments for Sugar

The prospects of including deficiency payments to supplement the modeled price support program and producers' incomes should be explored in light of extreme price and quantity variability. In essence, the deficiency payment would be based on a price differential between the target price and the market price multiplied by the quantity of raw sugar produced per harvested acre. These payments would be transferred to cane and beet producers if the market price over a specific period fell below the target price. With increased production specialization and limited land use alternatives, a deficiency payment combined with the modeled price support program would induce producers to allocate more resources to cane and beet production. Producers' income augmented through deficiency payments would be achieved through government transfer payments from taxpayers to the agricultural sector.

Furthermore, if producers' price expectations were significantly enhanced by deficiency payments, they should be willing to pay a higher price per acre for land dedicated to the production of cane. Substantial deficiency payments would eventually be reflected in the increase in the selling price or lease rent per acre of land when capitalized for present value purposes. If the expected deficiency payments were not substantial, the capitalization of land would be correspondingly small.

Table 27. Estimated Impact of Potential Sales (Output) Loss Resulting from the Demise of the Hawaii Sugar Industry, 1974-1981

Year	Sales Revenue of Sugar	Potential Loss in Sales Revenue
	(Millions of Dollars)	(Millions of Dollars)
1974	$ 695.2	$1,557.2 a/
1975	354.6	794.3
1976	245.5	549.9
1977	219.5	490.7
1978	269.5	603.6
1979	322.2	721.7
1980	566.4	1,268.7 a/
1981	314.2	703.8
Total 1974-81	2,987.1	6,689.9
Annual Average	373.4	836.2

a/ The price of sugar during this period was abnormally high, resulting from supply shortage in the domestic and international sugarcane- and sugarbeet-producing regions. The potential loss determined during this period is overstated compared with the other intervening years. The output multiplier is 2.24.

Hawaii Interindustry Analysis

The State of Hawaii Interindustry Model was used to assess the impact if the Hawaii sugar industry had become demised during the 1974–1981 period because of lack of an adequate price support program. The major plantations continued to operate during this period of negative returns in five out of eight years in anticipation of better prices and a very low supply response elasticity because of no viable alternative uses of land and equipment. This situation would have resulted in the demise of the industry in the long run. The estimates of output, income, and employment multiplier are based on data and multipliers for 61 Hawaii industries by the Hawaii State Department of Planning and Economic Development.

The output multiplier for the Hawaii sugar industry measures the volume of economic transactions within the industry engaged in providing factor inputs per dollar of additional final demand. The Type I multiplier measures the direct and indirect effects. This amounts to 1.3428, which means that an addition of one dollar in final demand for sugar will cause a change in output by all sectors of $1.34. Similarly, the Type II multiplier measures the direct, indirect, and induced effects resulting from consumer spending on sugar. The Type II multiplier is 2.2403 for each dollar of final demand for sugar. The higher the output multiplier, the greater the linkage with other industries. The absolute potential sales (output) loss resulting from

Table 28. Estimated Impact of Income Loss Resulting from the Demise of the Hawaii Sugar Industry, 1974-1981 a/

Year	Sales Revenue of Sugar	Potential Loss in Personal Income
	(Millions of Dollars)	(Millions of Dollars)
1974	$695.2	$891.1 b/
1975	354.6	454.5
1976	245.5	314.6
1977	219.1	280.8
1978	269.5	345.4
1979	322.2	413.0
1980	566.4	725.5 b/
1981	314.2	402.7
Annual Average	373.3	478.5

a/ The income multiplier is 1.28.

b/ The potential loss determined during this period is overstated compared with the other intervening years.

the demise of the Hawaii sugar industry during the period 1974–1981 based on the multiplier of 2.2403 would have been $836.2 million annually (Table 27). This assumes no alternative employment for all factors of production in the sugar industry. Although an absolute loss in such an event may be considered unrealistic, such an assumption is supported by the fact that, based on existing research, abandoned sugar acreage that could be used by viable alternative crops is extremely limited.

The income multiplier measures the addition to incomes of Hawaii households per dollar of income attributed to additional sugar revenue. The Type I income multiplier for sugarcane represents the additional dollar of household income generated with respect to direct and indirect effects. The Type II income multiplier for sugarcane represents the direct, indirect, and induced effects of each additional dollar of household income generated from sugar revenues. The Type I and Type II multipliers are 1.2071 and 1.9132, respectively.

To evaluate the impact of the demise of the sugar industry, the method developed by Hitch (1981) was adopted. Hitch concluded that for every dollar of income accruing to the sugar industry, $0.67 of personal income is distributed to Hawaii residents. The Type II income multiplier of 1.9132 multiplied by $0.67 generates $1.28 of personal income for Hawaii residents for each dollar generated from sugar. Table 28 indicates the potential income loss resulting from the demise of the Hawaii sugar industry during the period 1974–1981. If the sugar industry had been demised, with no alternative use of factors of production, the average annual loss for the 1974–1981 period would have amounted to $478.5 million for the state, or $495.80 per capita

Table 29. Estimated Impact in Potential Job Losses Resulting from the Demise of the Hawaii Sugar Industry, 1974-1981

Year	Total Sugar Employees	Total Sugar-related Unemployment a/
1974	9,350	19,724
1975	9,000	18,985
1976	9,000	18,985
1977	8,550	18,036
1978	8,500	17,930
1979	8,500	17,930
1980	8,400	17,719
1981	8,600	18,141
Annual Average	8,738	18,432

a/ The employment multiplier is 2.1095, which states that there are 2.1 jobs generated in the secondary and tertiary labor markets in support of jobs generated in the sugar industry.

(Table 28). This loss to the Hawaii sugar industry compares to an annual average additional cost of sugar to Hawaii consumers of only $4.6 million, or $4.77 per capita if sugar were supported during the research period (Table 5).

The employment multiplier measures the change in total employment in the Hawaii economy resulting from a one-unit change in employment in the sugar sector. The Type I and Type II employment multipliers are 1.246 and 2.1095, respectively. The Type I employment multiplier for sugarcane indicates that each person directly employed in the sugar industry is supplemented by .2461 additional individuals in allied industries. With respect to the Type II multiplier, for each person directly employed in the sugar industry, there are 1.1095 individuals in allied industries. Table 29 shows the number of sugar employees and the total number of employees who would have become unemployed as a result of the demise of the Hawaii sugar industry, an annual average loss of 8738 jobs in sugar and 18,432 jobs in total based on the employment multiplier of 2.1095.

Whereas an undetermined number of sugar workers would find jobs in other sectors, the loss of jobs caused by the demise of the sugar industry might be considered absolute in total, since sugar workers transferring to other jobs would displace other applicants seeking those jobs. Thus, total employment in Hawaii would have decreased by 18,432 workers during the period 1974–1981 if the sugar industry had become demised in an economy with substantial unemployment (7.2 percent) and no alternative employment for sugar-related workers except to displace workers in other sectors. In actuality, an undetermined number of dismissed sugar workers would have found employment that added to the total employment pool, but such opportunities are assumed to be minimal in Hawaii.

Implications for Hawaii's Sugar Industry

The scenario presented in the modeled price support program provides an average weighted cost-of-production valuation for the period 1974–1981. The Hawaii sugar industry has developed high-yielding varieties in a capital-intensive framework. However, Hawaii ranked highest of the sugarcane-producing states in costs of production per harvested acre of sugarcane during the research period due to the high cost of labor (Angelo and Hoff, 1983). Since there are no major alternatives to sugarcane production, Hawaii sugarcane producers are not responsive to price changes with respect to acreage planted. Demise of the sugar industry in 1981 would have resulted in 8600 fewer primary jobs and 9541 fewer secondary and tertiary jobs related to sugar, assuming no alternative employment opportunities.

If the industry were to become demised, some plantation and mill equipment might be subject to resale to U.S. mainland or foreign operations. However, in the majority of the mills, most of the equipment may already be fully depreciated or close to its depreciable life, thus resale revenue would be minimal.

Whereas the analysis in this study assumes an absolute and immediate demise of the Hawaii sugar industry without adequate price supports, there is some indication that it would take place gradually. The rationale is that most producers are under long-term lease agreements and have sugarcane plantings that will continue to be harvested to the termination date of the stand. Thus in some instances it would cost plantations more in the short run to close their field and mill operations than to incur annual losses through shutting down operations. This partially explains why the larger Hawaii sugar producers stayed in business during the period 1974–1981 in spite of the fact that costs of production exceeded gross revenue during three of the eight years. It is reasonable to assume that closing expenses in the form of severance pay, penalties for contract cancellations, and equipment and machinery liquidation losses would be foregone expenses at the time of mill closing.

Diversified agriculture is important for the continued success of Hawaii's agricultural base. The corporations that have traditionally dedicated prime agricultural lands to sugar and pineapple production are searching for viable alternatives, such as macadamia nuts, papayas, flowers, and foliage, that have export potentials to the U.S mainland and foreign countries. But so far, viable alternative crops can use only a comparatively small area of sugar lands.

Although the production of ethanol from sugar is not presently economically feasible in Hawaii, it may be of major importance to the future development of alternative energy sources for Hawaii.

U.S. Interindustry Analysis

In search of an appropriate output multiplier for the U.S. sugar industry, Type II multipliers were obtained for Louisiana cane sugar, 2.05; U.S. agriculture, 2.10; Texas agriculture, 2.40; and Hawaii cane sugar, 2.24. A cane sugar output multiplier for Florida would have been useful but was not attainable. The mean of the four multipliers was 2.20, and the mean of the multipliers for the three sugarcane-producing states was 2.23. Since these means were close to the Type II multiplier of 2.24 for Hawaii sugar, the latter was used for the U.S. sugar industry.

Table 30. Estimating the Impact in Potential Sales (Output) Loss Resulting from the Demise of the U.S. Sugar Industry, 1974-1981, New York Spot Price

Year	Sales Revenue of Sugar in Thousands of Dollars	U.S. Population in Thousands	Potential Loss in Sales Revenue Thousands of Dollars	Per Capita Share of Income Loss in U.S. Dollars
1974	$3,340,580 a/	213,361	$7,482,899 b/	$35.07
1975	2,831,220	215,353	6,341,933	29.50
1976	1,809,628	217,528	4,053,566	18.64
1977	1,338,362	219,684	2,997,931	13.65
1978	1,560,717	221,991	3,496,007	15.75
1979	1,799,306	224,431	4,030,445	17.96
1980	3,454,219	227,061	7,737,451 b/	34.08
1981	2,450,071	229,446	5,488,016	23.92
Annual Average	2,322,880	221,106	4,668,129	21.11

a/ The sales revenue is determined by multiplying the market supply in tons of raw sugar by the New York Spot Price. For example, in 1974 this amounted to 5,662,000 tons x $590 per ton.

b/ The price of sugar during 1974 and 1980 was abnormally high, resulting from supply shortages in the domestic and international sugarcane- and sugarbeet-producing regions. The potential loss determined during this period is overstated compared with the other intervening years. An output multiplier of 2.24 was used in this analysis.

Table 30 indicates the annual output loss that would have resulted if the U.S. sugar industry had become demised during the period 1974–1981. The losses incurred in 1975 and 1981 are overstated due to price abnormalities. If the U.S. sugar industry had been demised, the total loss for the 1974–1981 period based on the multiplier of 2.24 would have been $37.3 billion and the average annual loss would have amounted to $4.7 billion (Table 30).

The national annual loss of $4.7 billion during the study period, assuming absolute demise of the U.S. sugar industry with no alternative uses of factors of production, is substantial when compared with the programmed national annual reduction in consumers' surplus of $1.2 billion under the 20 percent *ad valorem* tax scenario (Table 24) or the $1.1 billion additional annual cost of sugar to consumers at the retail level resulting from the support program (Table 5).

An undetermined amount of the annual loss through demise would, of course, have been offset by partial shifting of the factors of production formerly used in sugar to other industries. Type II income multipliers were obtained for Texas agriculture and Louisiana cane sugar as well as for Hawaii cane sugar. Because of differences in the methods for obtaining the Texas and Louisiana multipliers, the Hawaii multiplier was considered to provide a better Type II income multiplier for U.S. sugar.

Table 31. Estimating the Impact of Income Loss Resulting from the Demise of the U.S. Sugar Industry, 1974-1981, New York Spot Price

Year	Dollars Per Ton	Sugar (Raw) 1000 Tons	Revenue in Thousands of Dollars	U.S. Population in Thousands	Potential Loss in Personal Income	Per Capita Share of Income Loss in the U.S. in Dollars
1974	$590.0	5,662	$3,340,580	213,361	$4,275,942	$20.04 a/ b/ c/
1975	449.0	6,300	2,831,220	215,353	3,623,962	16.83
1976	266.0	6,798	1,809,627	217,528	2,316,326	10.65
1977	219.8	6,089	1,338,362	219,684	1,713,101	7.80
1978	278.6	5,602	1,560,717	221,991	1,928,602	8.99
1979	310.6	5,793	1,799,305	224,431	2,303,117	10.26
1980	602.2	5,736	3,454,219	227,061	4,421,402	19.47 b/
1981	394.6	6,209	2,450,071	229,446	3,136,128	13.66
Annual Average			2,316,296		2,964,864	13.46

a/ The income multiplier for the U.S. was assumed to be similar to that of Hawaii, 1.28. This amount reflects the per capita share of income loss in the U.S. during the period from 1974 through 1981.

b/ The potential loss determined during this period is overstated due to the abnormally high prices that prevailed during these years.

c/ The per capita share of income loss is determined as follows: $3,340,580 divided by 213,361 is equal to $15.657 multiplied by the income multiplier of 1.28.

On the basis of Hawaii sugar multipliers, $0.67 of personal income is distributed to U.S. households for every dollar of income accruing to the sugar industry. The Type II income multiplier of 1.9132 multiplied by $0.67 generates $1.28 of personal income for U.S. households for each dollar generated from sugar. Table 31 shows the potential annual income loss resulting from the demise of the sugar industry during the period from 1974 through 1981. If the U.S. sugar industry had become demised, the total loss for the period would have been $23.7 billion and the average annual loss would have amounted to $3.0 billion (Table 31). The average annual per capita loss in income during the period would have been $13.46 (Table 31).

Retrospective losses for the 1974-1981 period if the total U.S. sugar industry had become demised should be taken with more caution than for Hawaii, since there are more alternatives for displaced factors of production for both cane and beet sugar on the U.S. mainland than for cane sugar in Hawaii. Assuming that factors of production in U.S. sugar production have their highest and best use in that industry, there would be an undetermined loss through the demise of sugar, ranging from minimal in some areas to very substantial in others. It seems reasonable to assume that the programmed annual loss of $4.7 billion through the demise of the sugar industry would not likely have been reduced by alternative employment of factors to a level equal to the $1.1 billion additional cost of sugar resulting from the superimposed price support program. A conclusive answer would require additional research on alternative opportunities for the factors of production, which is beyond the scope of this study.

SUMMARY AND CONCLUSIONS

Summary

The objective of this study is to superimpose in retrospect a modeled price support program for U.S. sugar on the essentially free market period of 1974–1981 and to compare this scenario with the free market scenario to determine consumers' welfare costs in relation to costs to society if the industry had become demised.

Research results indicate that an adequate price support program for the period 1974–1981 would have cost U.S. consumers an additional $4.77 per capita annually for sugar. The research also indicates that the estimated demand elasticities derived from the partial adjustment model during the period 1955–1981 are inelastic and that reductions in quantity purchased under the modeled price support program would have been minimal. It further indicates that demand elasticities during the period 1974–1981 were more elastic than for the period 1955–1981, thus suggesting that consumers would have changed their consumption very moderately in relation to changes in price.

Supply functions for cane sugar were derived for the purpose of obtaining short- and long-run price elasticities of supply. The primary focus is on expected prices and their influence on own-price elasticities for the respective cane-producing states. Estimated elasticities derived from linear supply functions from the regression for the period 1974–1981 are similar to the elasticities derived from the period 1955–1973. Estimated long-run elasticities derived for the United States and individual cane-producing states were more elastic for the period 1955–1981 than for the shorter research period of 1974–1981. Coefficients of adjustment indicated that producers changed their production only moderately in relation to changes in price.

To adequately determine acreage response during the 1974–1981 period, linear and double logarithmic partial adjustment models were adopted for estimating the respective acreage elasticities for cane-producing states individually and for beet-producing states combined. Overall acreage elasticity for the cane and beet states combined was inelastic in the short run, although this was not true for Florida and the beet states separately. Price elasticity of supply for Hawaii was not only highly inelastic, but was the lowest in comparison with other cane-producing states, indicating that Hawaii sugar producers are almost nonresponsive to changes in prices in the long run. On the other hand, the results indicate that Florida and the beet states are sensitive to changes in price and are highly supply responsive in the long run.

An important aspect of import barrier feasibility is to determine the impact of an import tariff on the U.S. economy and hence determine the welfare effects on consumers' surplus. The main focus in this study was to impose two tariff scenarios and to determine their effects on production and consumption deadweight loss, producers' surplus, tariff revenues, imports, and consumers' surplus. Research results indicate that annual per capita loss during the study period ranged from $1.76

under a $0.01875 duty rate to $6.08 under a 20 percent *ad valorem* tariff rate.

Annual average losses in revenue, income, and employment during the 1974–1981 period, if the U.S. sugar industry had become demised because of lack of an adequate price support program, would have been $4.7 billion annually in aggregate, or $21 per capita. The comparable loss to Hawaii resulting from the demise of the Hawaii sugar industry would have been $836 million annually in aggregate, or $880 per capita.

Conclusions

For the period 1974–1981, an essentially free market pricing system prevailed, characterized by severe variability in prices and supply. The research findings indicate that if the modeled price support program for the period 1974–1981 had been implemented, economic viability of the U.S. sugar industry could have been assured at little additional cost to consumers.

The following conclusions are derived from the study:

(1) The annual per capita cost of the modeled sugar price support program to the U.S. consumer would have been $4.77 during the research period, compared with an annual per capita cost of $21.11 if the industry had become demised with no alternative employment of factors of production.

(2) The modeled price support program during the period 1974–1981 would have provided more certainty in the allocation of scarce resources.

(3) Per capita demand for sugar under the modeled price support program for 1974–1981 would have been inelastic.

(4) Acreage response in cane and beet states under the modeled price support program would generally have been positively correlated with price changes.

(5) The potential per capita loss in annual revenue on a national basis would have been substantially greater than the cost of the support program if the U.S. sugar industry had become demised.

(6) The modeled price support program for cane and beet producers would have enhanced the stability of prices and incomes accrued to producers of high-fructose corn syrup.

The study is expected to be a valuable guide to policymakers for future sugar legislation. It provides a definite course of action relative to the issue of becoming largely self-sufficient in sugar in contrast to dependence on foreign imports to fulfill national demand requirements.

The study reinforces the concept that federal assistance may be necessary to keep a traditional industry such as sugar competitive with the rest of the world under price support and dumping policies by competing producing countries.

Need for Further Research

This study addresses consumers' welfare losses and the additional cost of sugar resulting from a price support program adequate to have kept sugar production viable during the research period in contrast to the cost of the demise of the industry without price supports. The study does not address the net cost resulting from the demise of the sugar industry after deducting the value of alternative employment of the factors of production. The latter would require comprehensive analyses of alternative employment opportunities for all segments of the U.S. sugar industry.

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