Economic Evaluation of Commodity Promotion Programs in the Current Legal and Political Environment

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Evaluating The California Table Grape Commission's Promotion Program: Overview and Summary

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Table grapes are one of the major fresh fruit crops grown in California. In 1993, California farmers shipped about 1.5 billion pounds of grapes to fresh markets, with a wholesale value of about $1.2 billion (Alston, Chalfant, Christian, Meng, and Piggott, forthcoming, 1997). Including grapes delivered to the wine and raisin industries, farm-level earnings of the California grape industry in 1993 were over $1.8 billion, a significant share of the total fruit and nut industry's farm production of $5.7 billion, making grapes the second most valuable commodity in California (California Department of Finance, 1995). In common with many other commodities grown in California (Lee, Alston, Carman, and Sutton, 1996), there is a state-authorized commission, the California Table Grape Commission (CTGC), funded by assessments on all marketings of fresh grapes, which funds and performs various activities to promote fresh grapes. To comply with recent court decisions mandating periodic evaluations of the effectiveness of promotional activities funded by mandatory assessments, the CTGC commissioned us to perform an in-depth econometric investigation of the effects on fresh grape prices and quantities, with specific attention to the impacts of the CTGC's promotional activities. A full description of that study is in Alston, et al. (forthcoming, 1997); in this article, we summarize our method and principal results.

The full study includes: (1) an overview of the history and institutional details of the California table grape industry, (2) an aggregate annual demand model of the North American market for fresh grapes and cost-benefit analysis, supported by a Monte-Carlo exercise, based on that model; (3) two disaggregated models of demand in North America (a model using monthly price and quantity data, and a model using monthly data for individual cities); and (4) an annual model of table grape exports, which was used in a cost-benefit analysis supported by Monte-Carlo simulations, with a supplementary model of grape demand in several important importing countries. A thorough and wide-ranging investigation is important in projects such as this, so that potentially important industry-specific issues can be identified and investigated, and so that models using very different data series can be estimated, to shed light on the confidence one may have in a specific set of results. This is particularly important when, as in the present case (and in common with many recent studies of the impact of mandated advertising and promotion programs) the estimated return to assessment dollars is very high. In addition to performing a wide-ranging evaluation of an important industry's promotional programs, we have spent some time examining functional forms, and show how a form imposing diminishing marginal returns to advertising can contribute to the resulting cost-benefit analyses. In addition, we argue that Monte-Carlo simulations should be used to develop confidence intervals of benefit-cost ratios, allowing variability of individual regression coefficients to be investigated in terms of the profitability measures that matter to those funding the promotional (or other) activities.

The History and Institutions of the California Table Grape Industry

Grapes for fresh (or table) uses are grown extensively in California, principally in the San Joaquin valley, with some production in the Sacramento Valley to the north, and substantial production in the desert valleys of the south. California is the dominant producer of grapes in the United States, accounting for roughly 97 percent of fresh grape production. The largest single variety is the Thompson Seedless, which while classified for some purposes as a "raisin-type" grape (most raisin vineyards are planted to Thompsons), is also grown extensively for the fresh market. About 40 percent of the 1994 shipments of fresh grapes were Thompson Seedless; the next most important variety was the red Flame Seedless, with about 28 percent.

The Thompson is a very versatile grape; in addition to its use in raisins and as a table fruit, it is also used for juice and for blending in some wines. However, there are limited opportunities for shifting production from one use to another, particularly in the modern industry. There are short-, medium-, and long-run reasons for limited substitutability in use. First, vineyards are now laid out and grown for different end uses. Vineyards to supply juice (including wine) are laid out with wide aisles to allow for mechanical picking, while raisin vineyards are also laid out with wide aisles, in which the grapes are laid for drying after hand-picking. Orchards supplying the higher-value fresh markets are often laid out with narrower aisles; since machines are not used to harvest fresh grapes, the space not needed for tractors is used instead to increase per acre yields.

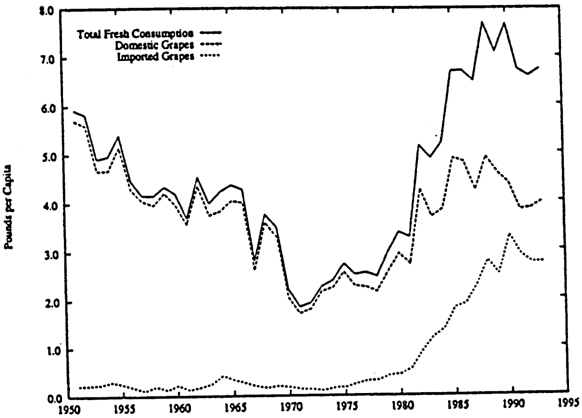
In the medium run, trellising systems vary for orchards specialized in different uses. Fresh markets require bunches of uniform, large, unblemished grapes; crushers are really purchasing fruit sugars, which are best supplied by more and smaller grapes, while appearance is not important; with raisins, sugar content is also important, while fungal infestations during drying have to be avoided. All of these factors influence the choice of the trellises upon which the vines are trained; while it is possible to retrellis after planting, this is expensive and is not normally undertaken during the life of a vineyard.

Finally, there are short-run decisions taken during the course of the season, which reflect grower decisions about the use to which the grapes will be put, again involving trade-offs between size, appearance, and juice content. Nonetheless, there is some switching, particularly from fresh-oriented vineyards into the juice crusher; normally this follows weather damage that reduces the fresh market value of the grapes, which are then sold to the crusher as a salvage operation.

In common with many other fresh fruits, per capita consumption of fresh grapes tended to fall (with some year-to-year fluctuations in response to weather events), from about 6 pounds in 1950 to under 2 pounds in 1970 (see Figure 1). Since 1970, the trend has reversed, with per capita consumption in the United States of domestic table grapes currently about 4 million pounds. In addition, starting in about 1980 there has been a major increase in fresh grape imports, mostly during the winter from Chile, although there have also been some imports from Mexico.

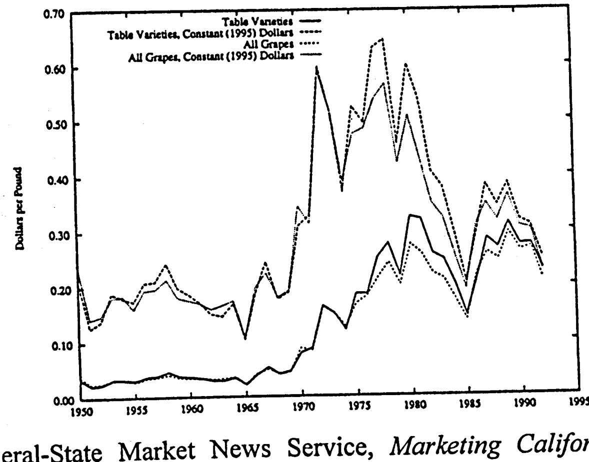
The great decline of per capita grape consumption, during the 1950s and 1960s, was accompanied on the one hand by a substantial increase in population, and on the other by approximately constant prices so that both total harvests and the value of harvests were without substantial trend during the period. After 1970, however, both quantities and (except for a downturn between 1980 and 1985) grower prices have tended to increase (see Figure 2). Year-to-year prices and harvests have fluctuated in opposite directions, following weather-induced supply shocks, yet over the period there has been a substantial increase in the real earnings of the table grape industry.

Figure 1. U.S. Per Capita Consumption of Fresh Grapes, 1950--93



Source: Federal-State Market News Service, *Marketing California Grapes, Raisins and Wine*, 1953 Season and 1968 Season. Federal-State Market News Service, *Marketing California Grapes for Fresh Use*, 1992 and 1993 Seasons. Sacramento: California Department of Food and Agriculture and USDA.

Figure 2.Average Grower Price of California Fresh Market Grapes by Variety Type, 1950-1992



Source: Federal-State Market News Service, *Marketing California Grapes, Raisins and Wine*, 1953 Season and 1968 Season. Federal-State Market News Service, *Marketing California Grapes for Fresh Use*, 1992 and 1993 Seasons. Sacramento: California Department of Food and Agriculture and USDA.

The CTGC was established in 1968, in part in response to the apparent stagnation in the fresh grape market and in part to help the industry respond to the challenges of events such as the UFW-initiated boycott of table grapes. The commission's activities have included public relations, the employment of marketing representative to maintain contact with grape wholesalers and retailers around the country, direct and subsidized purchases of media advertising, and other activities to encourage the sale and consumption of fresh grapes. That table grape consumption has grown substantially since the commission's formation is evident; the degree to which this is coincidence rather than the result of the commission's programs is the principal question that confronted us.

Impacts of Promotion in North America

Aggregate Annual Econometric Model

The core of our work was a time-series model of per capita shipments of fresh grapes to cities in Canada and the United States. We analyzed a single North American market for three reasons: first, using CTGC data one cannot identify the significant transshipments from northern U.S. cities to retailers and wholesalers in Canada; second, the two countries' recent demographic and economic histories have been similar; and third, in addition to substantial media spillover (principally from south to north) CTGC promotion policy towards the two countries has been very similar. In the case of table grapes, at least, there has been a single market in North America.

Shipments of table grapes are reported on a weekly basis by fresh grape packers, on the basis of which mandatory assessments are levied to support CTGC activities. The annual summaries of these shipment reports, tabulated for 1968-93, divided by the combined population of Canada and the United States, form Q_t, the dependent variable in the core econometric work (CTGC, 1968-93). For the grape price RPG_t we computed the average monthly price of Thompson Seedless grapes in the Los Angeles wholesale market, as reported by Federal-State Market News Service (1968-93), and deflated to 1995 dollars using the consumer price index (CPI). We investigated whether there were important cross-price effects with other fruits, using as a measure of the prices of these fruits the average of the CPIs for apples, bananas, and oranges. Our real expenditure measure $REXP_t$ is total consumption expenditures on all goods for Canada and the United States, with

Canadian expenditures converted into U.S. dollars using the annual average exchange rate, then deflated using the CPI and divided by total Canadian plus U.S. population to form real, per capita consumption expenditures. To measure the CTGC promotional effort, $RPROMO_t$, we extracted the advertising, public relations, and merchandisings expenses from the CTGC financial statements, and deflated them using the CPI.

In addition to the variables suggested by standard theory, we sought additional variables that might capture the effects of changes through time in the structure of the industry. We identified two specific structural changes that we thought might tend to increase demand through time. First, especially in the latter half of the estimation period, table grape imports from Chile grew dramatically. Since these are almost all off-season, we did not expect them to act as substitutes for California grapes. Rather, it seemed possible that by keeping grapes in front of consumers on a year-round basis, they might aid habit-formation, or they might ensure better display space in grocery stores devoted to grapes. We therefore constructed the variable $CHILE\text{-}IMP_t$, per-capita U.S. imports of fresh grapes from Chile. Second, we noted that over the period in question there was a substantial shift of grape supplies from seeded grapes to seedless, particularly the popular Thompson Seedless variety. More recently there has been growth in the production of red seedless grapes, particularly of the Flame Seedless variety. To capture the changing varietal composition of the fresh grape crop, we calculated $TS\text{-}SHARE_t$, computed as the number of lugs of Thompson Seedless shipped to fresh markets divided by total shipments of fresh grapes. Finally, we included a time trend.

The technical details of our estimation strategy, diagnostics, and investigation of model structure may be found in Alston, et al. (forthcoming, 1997). To summarize, we sought a final model quickly, which used weighted least squares and a dichotomous intercept dummy to account for a possible shift in the structure of the model between 1980 and 1981, using an equation that was linear in all the variables except for promotion, for which the square-root was taken. This has the advantage of imposing diminishing returns on promotional expenditures, as is strongly indicated by theory. An extensive battery of diagnostic tests were performed, searching for evidence of missing variables, misspecification of the error structure, and other econometric problems. The functional form of the equation was compared to other forms, including pure linear forms and single- and double-log specifications. Possible simultaneity of prices, promotion, and quantities was investigated. After this set of trials, we were confident that our estimated equation was useful for the conduct of a stochastic cost-benefit exercise.

The estimated equation, for the period 1969-93, was:

$$
\begin{array}{llllll}
(1)\quad Q_t = & 1.158 & -\ 1.281RPG_t & +\ 0.100REXP_t & +\ 0.519\sqrt{RPROMO_t} \\
 & [1.73] & [-5.41] & [1.61] & [5.45] \\
 & & (-0.51) & (0.51) & (0.16)
\end{array}
$$

$$
\begin{array}{lll}
+\ 0.040CHILE\text{-}IMP_t & +\ 1.541TS\text{-}SHARE_t & +\ 0.599D81\text{-}93_t \\
[0.23] & [2.29] & [3.08]
\end{array}
$$

$$R^2 = 0.97 \qquad \bar{R}^2 = 0.96 \qquad D.W. = 2.59$$

where the t-statistics are in brackets, elasticities at the means are in parentheses, and $D81\text{-}93_t$ takes the value 0 before 1981 and 1 after 1980. The equation fits the data very well, with coefficients that are of the signs predicted by theory. The price and income elasticities are plausible, in line with values frequently seen for specialty food crops (e.g., Alston, Carman, Christian, Dorfman, Murua, and Sexton, 1995). The coefficient on promotion is large, with an elasticity at the mean of 0.16. We would be more comfortable with a smaller value, but this large estimate is in fact the smallest of all the estimates from the various forms we fitted. Sometimes the data speak softly; in this case, they shout.

Benefit-Cost Analysis

We used equation (1) in a benefit-cost analysis of the CTGC's programs. Two analyses were performed, involving comparison of the actual history of prices, fitted quantities, and promotional expenditures to counterfactual scenarios where promotional expenditures were varied, and prices and quantities computed using various assumed elasticities of supply. We assumed constant-elasticity supply functions of the form:

$$Q_t = A_t R_t^{\varepsilon}$$

where

$$A_t \equiv \hat{Q}_t / R_t^{\varepsilon},$$

and R_t is the producer return per pound in year t, defined as $R_t = (1-\tau_t)P_t$ where τ_t is the actual promotional expenditure per pound consumed in year t, expressed as a fraction of the market price in year t (i.e., the rate of assessment required to finance actual promotional expenditure). A_t is a parameter that varies from year to year to ensure that given the actual values of prices and the other exogenous variables, each year the supply equation passes through the points defined by the predicted quantities from the demand model, written here as Q_t.

For any shift of supply or demand function, one can compute in year t, a counterfactual equilibrium producer return $R_t^{'}$ and quantity $Q_t^{'}$, and change in producer surplus:

$$\Delta PS_t = \frac{R_t^{'}Q_t^{'} - R_t Q_t}{1+\varepsilon}$$

One counterfactual scenario assumed that there had been no CTGC promotional expenditures at all; it is assumed that in each year the demand function shifted in by the square root of that year's promotional expenditures times the coefficient in (1) on $RPROMO_t$. When divided by a measure of the cost of the program, one has a measure of the *average* benefit-cost ratio. The other counterfactual scenario is that instead of its historic values, in each year CTGC expenditures were 10 percent higher; in each year the equilibrium price and quantity are computed under that assumption. For each assumed supply elasticity ε =(0, 0.5,1.0,2.0,5.0), and for each counterfactual scenario, two simulations were performed:

- using hypothetical values for the promotional expenditure in every year (either 1.1 times the actual values or zero promotional expenditure) with actual assessment rates; and

- using hypothetical values for the assessment rate in every year (either 1.1 times the actual values or zero assessments) with actual promotion expenditure;

The first pair of simulations yields the marginal and average producer surplus associated with the promotion-induced demand shifts, while the second pair yields the incidence on producers of the assessments necessary to fund those promotions. In addition to the producer incidence of the assessments, we also used the total cost of the promotional programs; this allows us to compare producer benefits to the total social cost of the promotional programs (including the incidence on consumers of the assessments). Our full set of benefit-cost ratios, using the regression estimates of the demand parameters, are shown in Table 1.

The consequence of a large demand elasticity is readily apparent: the lowest ratio of producer benefits to producer costs is almost 80 to 1. Even when all costs are included, and when supply is quite elastic (so that a 10 percent increase in price calls forth a 50 percent increase in fresh grape deliveries), the benefit-cost ratio exceeds 5 to 1. As noted above, we do not believe that supply in this industry, or in other perennial fruit crops, is anywhere near this elastic except possibly over a rather long period, substantially longer than the single year for which promotion and assessment decisions are made. Nonetheless, even with this unrealistic assumption, the CTGC expenditures have been quite profitable, particularly from the standpoint of the growers and packers who have paid the assessments financing the promotion programs.

Of course, the regression estimates of the demand parameters are themselves random variables, as are the resulting measures of benefits and costs in Table 1. To develop confidence intervals for these measures, we used joint probability distribution of the estimation errors for the various estimated demand parameters in equation (1) to generate 10,000 random draws of the coefficient vector and, therefore, 10,000 sets of benefits and costs (noting that the total expense measure does not vary). These simulations yielded a lower 99 percent boundary for the benefit-cost ratios, above which 99 percent of the calculated ratios were found; this boundary was 40 to 1 the case of the marginal producer-benefit to producer-cost ratio, and over 75 to 1 in the case of the equivalent average ratios, regardless of elasticity of supply or discount rate. Even in the case of highly elastic supply and a comparison of producer benefit to producer cost, the 99 percent boundary is at least 3 to 1. Again, the data are unequivocable: the CTGC promotional programs have offered benefits to the industry far in excess of their costs.

Table 1. Benefits and Costs of Table Grape Promotion

	Supply Elasticity				
Series	**0**	**0.5**	**1.0**	**2.0**	**5.0**
0 percent compounding					
Average benefits, costs:					
Present value, producer benefits	19,876.5	6,589.8	4,322.6	2,606.5	1,205.8
Present value, producer cost incidence	115.2	46.1	29.4	17.1	7.6
Present value, total program expenses	115.2	115.2	115.2	115.2	115.2
Producer benefits/producer costs	172.5	143.0	147.1	152.1	157.9
Producer benefits/total expenses	172.5	57.2	37.5	22.6	10.5
Marginal benefits, costs:					
Present value, producer benefits	970.1	380.1	240.2	139.0	61.6
Present value, producer cost incidence	11.5	4.6	2.9	1.7	0.8
Present value, total program expenses	11.5	11.5	11.5	11.5	11.5
Producer benefits/producer costs	84.2	82.2	81.5	80.8	80.3
Producer benefits/total expenses	84.2	33.0	20.8	12.1	5.3
3 percent compounding					
Average benefits, costs:					
Present value, producer benefits	25,964.1	8,992.2	5,939.9	3,603.2	1,676.0
Present value, producer cost incidence	153.3	63.7	41.0	24.1	10.8
Present value, total program expenses	153.3	153.3	153.3	153.3	153.3
Producer benefits/producer costs	169.4	141.2	144.9	149.6	155.2
Producer benefits/total expenses	169.4	58.7	38.8	23.5	10.9
Marginal benefits, costs:					
Present value, producer benefits	1,267.3	516.0	329.5	192.2	85.7
Present value, producer cost incidence	15.3	6.4	4.1	2.4	1.1
Present value, total program expenses	15.3	15.3	15.3	15.3	15.3
Producer benefits/producer costs	82.7	80.8	80.1	79.5	79.0
Producer benefits/total expenses	82.7	33.7	21.5	12.5	5.6

Disaggregated Econometric Models

Two additional econometric exercises were carried out using different sets of data from those used in the annual aggregate model to validate the results used in our benefit-cost work. The first of these took shipments by month, for the period 1972-93 (since monthly data were not available before then), divided by population, to form the dependent variable. Explanatory variables were as before, except that the grape price was the monthly average wholesale price for Thompson Seedless grapes in Los Angeles, again deflated by the annual CPI. In addition, monthly dummy variables were introduced for all months except December, which was selected as the base month, and for February, March, and April, off-season months for which prices and/or quantities were missing from the data set. Annual data were again used for promotional expenditures; in addition, equations were estimated where advertising, merchandising, and public relations had separate coefficients.

Details of this phase of the econometric work may be found in Alston, et al. (forthcoming, 1997), Chapter 4. The results matched up very well with the work described above; they confirmed and reinforced those from the annual model estimated over essentially the same period. In the monthly model, monthly per capita quantities consumed were determined by the real price of grapes and monthly dummy variables, all of which varied monthly within a year, and other variables that were constant across months within a year but that varied across years (real per capita income, Chilean imports, the Thompson Seedless share, and most importantly, real annual expenditure on promotion). Tests indicated that it was sufficient to use aggregate promotion, rather than to disaggregate into individual elements -- advertising, merchandising, and public relations -- although a case could be made for dropping the expenditure on public relations from the model while still combining advertising and merchandising. As with the annual model, it was difficult to distinguish between the linear and square root models. In both forms, there were mild problems of autocorrelation and heteroskedasticity, but correcting for these problems did not affect the estimates appreciably.

The main conclusion was that the monthly results reinforced our confidence in the estimates of effects of prices and promotion on consumption of table grapes, from the annual model. In turn, this added to our confidence in the use of the parameters from the annual model in a benefit-cost analysis of the commission's promotional program and in the estimates obtained from that benefit-cost analysis.

A second set of monthly models used detailed, city-specific data on prices and quantities of table grapes -- quantities were obtained from the commission's records of shipments, and daily market news reports from the USDA were used for prices. We modeled table grape demand in the aggregate, combining all varieties. We then combined the daily and weekly quantities and prices to create a monthly data set for each of 17 cities. To aggregate across quantities, we summed the quantities (i.e., we did not create a quantity index, weighting individual quantities according to their value shares), creating a measure of per capita consumption of all California table grapes for each city being studied.

We also constructed city level indexes of the price of grapes. In modeling the monthly and annual aggregate demand for grapes, we used the Thompson Seedless price in Los Angeles as a proxy for an index of the national price for all grapes. This was necessary because detailed prices and quantities of the individual varieties were not available for the complete time series. However, disaggregating by city meant that we had a considerably greater number of monthly observations, even using data only from 1992 and 1993, and we did have a fairly complete set of monthly prices and quantities, by variety, for those years. We constructed a simple price index by weighting the price for each of seven major varieties (for which we had information on both price and quantity) by the share of that variety in the total quantity of those varieties. Our monthly price and quantity data for 12 cities were combined with demand shift variables that either matched those from the aggregate U.S. models already described, or represented city-level counterparts. We did not have city-level or monthly breakdowns of the quantity of grapes imported from Chile, so only the annual *CHILE-IMP* used in the aggregate annual and monthly models is available. Similarly, while we did have city-level measures of personal income, these were annual not monthly. Monthly variations in income or expenditures probably have little relevance in explaining month-to-month variations in grape consumption, in any event. We tried the price of apples as a measure of the price of a substitute, but it was never statistically significant. Finally, we did not have city-by-city breakdowns of total promotion, *RPROMO*.

We used one promotion variable that was available on a city-by-city and month-to-month basis, the sum of expenditures on radio and television advertising divided by the corresponding value of the CPI, to obtain the real expenditure measure, *RADIOTV*. Ideally, one would divide by an index of the cost of advertising, but we did not have such an index, so we used the CPI as a proxy. It could also be argued that dividing by population is appropriate, to obtain a measure of per capita advertising, especially if the cost of advertising but not the CPI increases proportionally with the size of the audience (i.e., the size of the metropolitan region or CMSA). In keeping with our previous models, however, we chose to use the total *RADIOTV* value, rather than include the real expenditure on a per capita basis.

We were unable to account specifically for the effects of other promotion or of imports from Chile, since only aggregate annual data were available on these variables. With only two years of data, changes in both imports from Chile and *ROTHER*were econometrically indistinguishable from changes in the intercept or any other shifts that occurred between the two years, but were common to all cities and months. Without variation across cities in these variables, however, they cannot do anything except serve as proxies for all of these year-to-year differences. A year dummy for 1992 (i.e., making 1993 the default year) was included, analogous to the monthly or intercept dummies in previous models, so we did not (in fact, could not) include either imports from Chile or *ROTHER*.

Since the income variable varies across cities, we can still include it in our demand model, even though it does not vary among months for a given city. To obtain a measure of real income, we divided our annual income variable by the July CPI for each city-year combination. While the CPI is available on a monthly basis, we did not want to divide the annual income variable each month by a different monthly cost-of-living index, because this would introduce artificial variation in real income due solely to observing the CPI more frequently than income. In reality, income and the price level both change throughout the year, so using July's CPI seemed like a good compromise. Finally, this real income variable was divided by the annual population figure for the CMSA.

As in our other models, to calculate per capita quantities, we divided total monthly shipments by population. We divided our index of grape prices by the city-specific CPI, to obtain a real grape price, RP_t, and used the real income and advertising variables already described, to obtain the demand model:

$$Q_{imt} = \beta_0 + \beta_p RP_{imt} + \beta_{RTV} RADIOTV_{imt} + \beta_{INC} RINC_{it} + \beta_{92} D92_t + e_t,$$

where Q_{imt} is per capita consumption of fresh grapes in city *I*, month *m*, and year *t*, RP_{imt} is the real wholesale price index of table grapes, calculated from varietal prices using quantity weights, $RADIOTV_{imt}$ is CTGC spot radio and television expenditures, $RINC_{it}$ is annual real per capita personal income in city *I* and year *t*, and $D92_t$ is one when $t = 1992$ and zero otherwise.

It was necessary to account for apparent dynamic effects in this model. With sufficiently disaggregated data, the effect of promotion may extend after the period in which expenditures are tracked. For instance, an advertising expenditure in August may lead to increased demand in both August and September. We therefore used a variable called *MAD* instead of *RADIOTV*, where *MAD* represents a moving average of *RADIOTV* values. We varied the number of months from two (representing persistence of *RADIOTV* for one month beyond the current one) to six, and took the square root of the moving average, called *R-MAD*, analogous to the treatment of promotion in the preferred aggregate model. Thus:

$$R-MAD2_t = \sqrt{\frac{1}{2}RADIOTV_t + \frac{1}{2}RADIOTV_{t-1}},$$

$$R-MAD3_t = \sqrt{\frac{1}{3}RADIOTV_t + \frac{1}{3}RADIOTV_{t-1} + \frac{1}{3}RADIOTV_{t-2}},$$

and so on, for longer lags. Finally, we selected data from June through December, to focus on those months when *RADIOTV* and shipments of the important varieties were concentrated.

Again, detailed results of the estimations may be found in Alston, et al. (forthcoming, 1997). It suffices to mention that here price, income, and promotion coefficients had the signs predicted by theory; price and income elasticities were plausible and similar to those found in the aggregate models, and the advertising coefficients were statistically significant. We had some success in measuring a three-month ``wearout'' of the effects of advertising, although this measurement applied as well to any other demand shock in the model.

Promoting Exports of California Table Grapes

Exports of fresh table grapes have accounted for between 10 and about 30 percent of California's annual shipments since the early 1950s, reaching 31.4 percent in 1991 and 30.4 percent in 1993. As can be seen in Figure 2, the trend in the quantity of table grape exports was fairly flat until the late 1980s. Since 1987, exports have grown from between 200 and 250 thousand pounds per year -- a range sustained since the 1960s -- to over 400,000 pounds per year in the 1990s.

The principal export destinations for California table grapes have changed over time. Canada remains the primary non-U.S. market, but was included with the United States in the analysis above. In the past, European markets were important destinations for exports, but the more recent emphasis and growth of California's exports have been in Asian markets, and most recently Mexico, following the implementation of NAFTA. The California Table Grape Commission's export promotion program has targeted the primary Asian destinations: Hong Kong, Taiwan, Malaysia, and Singapore. Accordingly, the focus of our analysis of export demand and demand response to advertising and promotion is on Asian markets.

The export promotion programs have been financed with the assistance of the U.S. government, and have been relatively more intensive than in domestic markets: while consuming around 30.4 percent of total shipments in 1993, export markets attracted around 62 percent of total promotional expenditure.

We developed two sets of models. First, we studied aggregate demand for U.S. grapes in eight primary importing countries (Hong Kong, Taiwan, Malaysia, Singapore, the Philippines, Indonesia, Thailand, and South Korea), using annual data on real per capita consumption, the real price of table grapes, real per capita income, and promotion, for the period 1976-1994. The results were used to simulate the market and calculate a benefit-cost ratio, with measures of precision, as was done with the aggregate annual U.S. model. Second, monthly data for the period 1986-1994 for four individual countries -- Hong Kong, Malaysia, Singapore, and Taiwan -- were modeled, primarily as a check on the results from the aggregate annual export demand model.

Aggregate Annual Econometric Model of Exports

Aggregating models of demand across different countries was made difficult by the fact that different countries have different currencies. The use of market exchange rates to convert currencies to comparable units can be justified if per capita income differences are not too great, but is not a perfect solution (purchasing power parity indexes may be better, but involve their own set of problems). There may be other sources of international differences in demand, too. Often, cultural differences among countries have important implications for demand relationships, while sometimes income differences are very large among countries, making typical consumption patterns different. Also, it is often difficult to develop meaningful measures of prices of relevant substitutes. Simple aggregation that treats all countries as being alike in terms of their demand response parameters, may be perilous in such circumstances. However, at the same time there can be gains from aggregation, which reduce the role of random variation among individual units of observation.

These types of problems are not different in kind from problems that arise in aggregating across individuals or regions within a country, but they may be more important -- especially if the differences among countries are more important than the differences across regions within a country. The countries included for analysis in this part are relatively similar countries in terms of per capita incomes and other aspects, and their currencies have been relatively stable in relation to the U.S. dollar, so the aggregation of these countries for the present analysis may not be too problematic. The Asian countries included here accounted for around 51.6 percent of table grape exports in 1994.

We constructed a relatively simple model in which the per capita consumption of California table grapes in the selected Asian countries, X_t in year t, depends on the real unit value of all California table grape exports (total value of exports to those countries divided by total quantity), RPG_t, real per capita income (total expenditure) in those countries, $REXP_t$ and the real value of export promotion in those countries, $RPROMO_t$. All of the monetary variables were expressed in real 1995 U.S. dollars (by dividing by the United States CPI) set equal to one in 1995. We did not have available a meaningful price of an individual alternative commodity to regard as a substitute for grapes. The deflation by the CPI can be thought of as a way of treating all other goods as a general substitute for grapes.

Since only 19 years of data are available, we limited the specification search to considering a linear model, and a model that is linear except the inclusion of the square root rather than the level of promotion, which we call the square root model; each with and without a time trend. These alternatives were suggested by our results above using U.S. data. Detailed results and other discussion of the econometric work is in Alston, et al. (forthcoming, 1997), Chapter 5.

As in the work on demand in North America, the square root model is preferred. This model can be written as:

$$
(2) \quad X_t = \begin{array}{cccc} 0.119 & -\ 0.253 RPG_t & +\ 0.347 REXP_t & +\ 0.149\sqrt{RPROMO_t} \\ [0.81] & [-1.64] & [3.01] & [3.37] \\ & (-0.48) & (0.85) & (0.21) \end{array}
$$

$$
R^2 = 0.95 \qquad \bar{R}^2 = 0.94 \qquad D.W. = 1.35
$$

where the numbers in brackets are *t*-statistics and elasticities at the means are in parentheses. The R_2 indicates that this simple model accounts for a very high proportion of the variation in per capita consumption. The coefficients are consistent with plausible values for elasticities of demand with respect to price (-0.48), income (0.85), and promotion (0.21). The price coefficient is not statistically significant from zero, however.

The Durbin-Watson statistic suggests that there might be some autocorrelation problems. In fact, the estimated first-order autocorrelation coefficient, 0.36, is not statistically significantly different from zero. Diagnostic tests were applied to the preferred model, using the DIAGNOSTIC procedure in *SHAZAM*. Using these tests, we could not reject the hypothesis of a constant error variance, nor the hypothesis of a stable model structure across the sample period.[1] Even though the model fit well, we regarded these results as somewhat tenuous, since they have been obtained from a very simple model, aggregating across a number of different countries, using unit value data rather than prices, and in which the estimated price response was statistically insignificant; and we have not searched for the best specification.

Benefit-Cost Analysis

As for the domestic demand model, we used the model of export demand to simulate counterfactual scenarios and develop estimates of benefits of export promotion. To do this, we required a model of supply to the export market. In a competitive market, the export supply function can be represented as an excess supply function, given by the difference between total supply and domestic demand. The elasticity of the excess supply function is then given by the following formula:

$$(3) \qquad \varepsilon_g = \frac{Q}{X}\varepsilon + \frac{Q-X}{X}\eta$$

where Q is total production, X is the quantity exported, ε is the domestic supply elasticity, η is the absolute value of the domestic demand elasticity, and ε_x is the export demand elasticity. Thus, the export supply function becomes more elastic as either total supply or domestic demand becomes more elastic and as the fraction of production exported increases. Suppose 25 percent of production is exported, and the domestic demand elasticity is -0.5. Then, even if total supply were fixed ($\varepsilon = 0$), the elasticity of supply of exports would be 1.5. Any domestic supply response to price would add to the export supply elasticity.

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[1] The Maximum Chow test indicated a possible structural change at the mid-point of the data, but the test was only nominally significant at the 5 percent significance level and not at the 1 percent significance level. Since the nominal significance overstates the true significance when the test is conducted sequentially, this test probably should be regarded as not rejecting a stable model over the data at the 5 percent significance level (Alston and Chalfant, 1991). However, it does mean that, if applied to the midpoint, a conventional Chow test would reject the stability hypothesis.

We used the same model structure as for the domestic market discussed above: the estimated demand model and a constant elasticity export supply function. We solved for the equilibrium prices and quantities, using the 10,000 replications and using the actual values of promotion, zero promotion, and a 10 percent increase in promotion.[2] We also simulated the incidence of the application of a checkoff to raise the funds to pay for the changes in promotion being simulated. An important difference in interpretation arose because the consumers, in this case, were not Americans. And, at the same time, the source of the funds may not be table grape consumers and producers, since the funds may be provided from general government revenues rather than a producer checkoff. Since the simulations were conducted using an export supply function, the corresponding measure of "producer surplus" was, in fact, net domestic surplus, reflecting induced changes in welfare of both producers and domestic consumers when price changed.

The assessment modeled, in this case, acts similarly to an export tax, whose incidence is partly on exporters and partly on foreign consumers. In reality, the assessment is on all grapes sold as fresh and not just on exports, so the incidence should be divided between foreign and domestic consumers, and producers. Since the bulk of foreign promotion is paid by the government through MAP and predecessor programs, it is probably most accurate to consider the "Total Expense" as the cost measure, with no distribution of incidence. See Kinnucan and Christian (forthcoming, 1997) for a return assessment that incorporates both elasticities and assessment rates.

Table 2 shows the results of the simulations using supply elasticities to the export market of 1, 2, 5, and 10, combined with the point estimates of the parameters of the demand model. Consider the figures using no discounting and a supply elasticity of 5, in the third column of the upper half of the table.The first entry in this column indicates that over the 19-year period, total U.S. benefits from export promotion in these Asian markets were $79.5 million. The next entry down

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[2] In this set of simulations, a significant fraction of draws were discarded, since they implied positive values for the demand elasticity. This situation arose because the precision of the estimate of the slope of demand with respect to the price of grapes was low: given a *t* value of 1.64 with 14 degrees of freedom, between 5 and 10 percent of the draws of that parameter would be positive numbers.

shows that the total domestic-market incidence of costs (if an export assessment had been used to finance that promotion) would have been $1.2 million over the same period. The next entry down is simply the amount spent on promotion, $23.8 million, also over the same period. The value of the ratio of the total domestic benefit to the domestic incidence of the export assessments to finance the full amount is over 64:1. The fifth and final entry in this set shows that the value of the ratio of the total domestic benefit to the total cost of promotion is over 3:1, still a high benefit-cost ratio. This measures the *social* benefit-cost ratio in the case where the promotion is fully funded by general government revenues, costing one dollar to the United States per dollar spent.

The next set of five entries in the same column refers to the same measures of benefits and costs, but considers a marginal increase of 10 percent rather than looking at total benefits relative to the total promotional expenditure. The first entry in this group indicates that, in total over the 19-year period, the United States would have benefited by $4.1 million if the export promotion expenditure had been increased by 10 percent over the actual value in each year. The next entry down shows that the total domestic cost, had export assessments been used to finance that additional promotion, would have been $0.1 million over the same period. The next entry down shows that the cost of spending an additional 10 percent on export promotion in every year would have been $2.4 million over the 19-year period. The ratio of the marginal domestic benefit to the domestic incidence of the assessments is 32:1, a little over half the corresponding average benefit-cost ratio. The fifth and final entry in this set shows the mean value of an additional 10 percent expenditure on export promotion in every year. The ratio is about 2:1; also a little over half the value of its counterpart considering average rather than marginal benefits and costs.

As in the domestic model, we used information about the joint probablility distributions of the estimation errors of the regression parameters to conduct a Monte-Carlo exercise, giving a 99 percent confidence interval for the various benefit-cost measures. We found that if a very pessimistic view is taken, the benefit-cost ratios could be quite respectable, but might fall below one depending on the value for the supply elasticity and the method of financing the promotion.

Table 2. Benefits and Costs of Grape Export Promotion

	Supply Elasticity			
	1.0	**2.0**	**5.0**	**10.0**
0 percent compounding				
Average benefits, costs:				
Present value, U.S. benefits	281.4	170.9	79.5	42.2
Present value, U.S. cost incidence	5.0	2.8	1.2	0.6
Present value, total program expenses	23.8	23.8	23.8	23.8
U.S. benefits/U.S. costs	56.5	60.5	64.4	66.1
U.S. benefits/total expenses	11.8	7.2	3.3	1.8
Marginal benefits, costs				
Present value, U.S. benefits	16.2	9.3	4.1	2.1
Present value, U.S. cost incidence	0.5	0.3	0.1	0.1
Present value, total program expenses	2.4	2.4	2.4	2.4
U.S. benefits/U.S. costs	31.9	32.1	32.3	32.4
U.S. benefits/total expenses	6.8	3.9	1.7	0.9
3 percent compounding				
Average benefits, costs:				
Present value, U.S. benefits	328.9	200.9	94.0	50.0
Present value, U.S. cost incidence	5.7	3.2	1.4	0.7
Present value, total program expenses	26.3	26.3	26.3	26.3
U.S. benefits/U.S. costs	57.9	61.9	65.9	67.7
U.S. benefits/total expenses	12.5	7.6	3.6	1.9
Marginal benefits, costs				
Present value, U.S. benefits	18.8	10.9	4.8	2.5
Present value, U.S. cost incidence	0.6	0.3	0.1	0.1
Present value, Total program expenses	2.6	2.6	2.6	2.6
U.S. benefits/U.S. costs	32.5	32.8	33.0	33.2
U.S. benefits/total expenses	7.1	4.1	1.8	1.0

Comparing domestic benefits with the domestic incidence of the assessments, the estimated average benefit-cost ratio is around 24:1, and the marginal benefit-cost ratio is around 2.4:1. Comparing domestic benefits with the total cost of the expenditure, the estimated average benefit-cost ratio lies between 0.5:1 and 4:1, and the marginal benefit-cost ratio lies between 0.3:1 and 2:1, depending on the supply elasticity.

National Import Demand Models for Table Grapes

As in the case of the North American demand model, we supplemented our aggregate export model with a disaggregated study using different data, in this case an analysis of four specific markets, using monthly data for nine years (1986-1994). The countries were: Hong Kong, Malaysia, Singapore, and Taiwan. The model was essentially the same as was used above for the aggregated annual export data. For the individual country studies, however, we included two separate promotion variables, the real value of advertising expenditure and the real value of other promotional expenditure, with both variables included in square root form. Thus, the import demand models for the four countries took the form:

$$X_{it} = \beta_{i,0} + \beta_{i,PG} RPG_{it} + \beta_{i,EXP} REXP_{it} + \beta_{i,BRA} \sqrt{ROTHPROMO_i} t,$$

for each country *i*. All of the monetary variables were expressed in real U.S. dollars. The models for the four countries were estimated as a system of equations, using seemingly unrelated regressions (SUR) to take account of the possibility of contemporaneous correlation of the error terms across the equations for the different countries. We did not impose any equality restrictions on the parameters across the equations, since there seemed to be important differences in the demand relationships that would have been repressed by imposing such restrictions, and there seemed to be little to be gained. The detailed results of this analysis are in Alston, et al. (forthcoming, 1997). These results were reasonably satisfactory overall.

In every country, the coefficients on both the advertising variables were positive. In Singapore, however, the coefficient on the square root of real advertising, *RAD*, was not statistically significantly different from zero. And the coefficient on the square root of other promotion, *ROTHPROMO*, was not statistically significantly different from zero in three of the countries; Malaysia was the exception. Interestingly, the point estimates implied a narrow range of elasticities of demand with respect to both of the promotion variables, at the sample means, among the four countries. The elasticity of demand with respect to real advertising, *RAD*, ranged from 0.03 to 0.11; the elasticity of demand with respect to other promotion, *ROTHPROMO*, ranged from 0.05 to 0.15.

In short, with the exception of Singapore, the models indicated that promotion, especially advertising, has had a statistically significant, positive effect on demand for California table grapes in each of the countries. Even in Singapore, the results were suggestive of a positive effect. These results reinforced the results above using aggregate annual data for a larger number of Asian countries over a longer time period, although the monthly elasticities of demand response to promotion in the individual countries were somewhat smaller than in the annual aggregate model.

Discussion

The different models, using data for different markets, or using data collected at different frequencies or over different time periods, tell remarkably similar stories about the nature of demand for California table grapes, and the demand response to promotion. In every case, the analysis indicated that a linear model of demand, with the promotion variable entering in square root form, was preferred. A wide range of tests against alternative functional forms was tried with the aggregate annual model, in particular. The preferred model allowed diminishing marginal returns to promotion, which is a desirable feature.

Price Elasticities

The preferred aggregate annual demand model (equation (1)) indicated an own-price elasticity of demand for California table grapes equal to -0.51 at the mean of the sample data. This is a plausible value, entirely in keeping with prior expectations. Most fruits would be expected to face inelastic demands (e.g., George and King, 1971). The price elasticity estimates in the disaggregated models were somewhat smaller, although the difference was probably not statistically significant. It may well be that the true monthly demand elasticities were smaller than annual ones -- sluggish adjustment or habit persistence in consumption patterns would imply that shorter-run elasticities are smaller.

The estimated own-price elasticities from the export demand models were consistent with both prior expectations and the domestic demand models. In the preferred aggregate annual export demand model, the own-price elasticity of demand for California table grapes was estimated at -0.48. In the individual monthly demand models for selected countries, the elasticity ranged from -0.47 to -1.43, generally not statistically significantly different from -0.48.

Income Elasticities

We were somewhat less successful in estimating the elasticity of demand with respect to income (or total expenditure on all goods), which is a common outcome in time-series models of demand. The fact that per capita income tended to follow a smooth trend made it difficult to accurately measure demand response to changes in income; cross-sectional data contain more useful variation in income and are probably better for measuring the relevant income effects. In the aggregate annual model, the estimated income elasticity was 0.51, which is plausible, but the parameter was not (quite) statistically significant. In the aggregate monthly model, the coefficient was negative but not statistically significant. In the city-month model using cross-sectional data, the income elasticity was estimated as 0.41, consistent with the annual model and statistically significant. Finally, in the aggregate export demand model, the income elasticity was estimated as 0.85 and statistically significant. A higher income elasticity would be expected to be found in countries having lower per capita incomes, so this was plausible and consistent with the results for the United States.

Demand Shift Variables

Time-trend variables were tried in the demand models, but were never found to contribute significantly to the regressions. There was some evidence of discrete structural change in the aggregate model. In the aggregate annual demand model, specific demand shifters included the Thompson Seedless share (the effect was positive and statistically significant) and the quantity of imports from Chile (a positive effect, but not statistically significant). A similaar story held with the monthly aggregate demand model. Increases in both Chilean imports and the

Thompson Seedless share were estimated to have positive effects on demand, but in the monthly model, the effect of Chilean imports was statistically significant, while that of the Thompson Seedless share was not; a reversal compared with the annual model. There is some evidence, then, that both of these variables may have contributed positively to demand.

Promotion Variables

The demand shifter of greatest interest for the present study is promotion. As noted above, in every case, we preferred models in which promotion variables entered in square root form. In the aggregate annual demand model (equation (1)), the effect of promotion was positive and statistically significant: the elasticity of demand with respect to promotion at the mean of the sample data was 0.16. In the aggregate monthly model, the effect of promotion was also statistically significant. In the city-level monthly demand model, the effects of a moving average of radio and TV advertising expenditures was also statistically significant and positive. The elasticities of demand with respect to promotion were generally consistently high, well beyond the range that would sufficiently justify past promotional expenditures (as we will show later, given a price elasticity of -0.5, an expenditure on promotion of 2 percent of the gross value of sales would require an elasticity with respect to promotion of 0.01, much less than 0.16 or 0.30). Consequently, our estimates implied very high benefit-cost ratios, even when we made the most conservative assumptions (i.e., combining parameter values in ways that made the benefits relatively low).

Benefit-Cost Analysis

Benefit-cost ratios were very high, for both domestic and export promotion, using point estimates of parameters from the preferred models. This result followed from the (perhaps surprisingly) high estimated elasticities of demand response to promotion. Taking the parameters as being measured precisely, the results indicated that the program has been very profitable for producers. Alternatively, if we were uncertain about the exact value of the parameters, the results can be taken as indicating that our estimates would have to be wrong by a great margin before we would change our conclusion that the benefits have been greater than the costs. Indeed, even looking at the 99 percent lower bound from our Monte Carlo simulations for domestic promotion, the benefit-cost ratios were substantially greater than one.

The high marginal benefit-cost ratios may be taken as indicating that it would pay to increase the expenditure on promotion and the assessment used to finance promotion. Comparing the benefit-cost ratio from domestic promotion with the lower ratio from export promotion could be taken as an indication that it would be profitable for the industry to divert promotional resources from the export market to the domestic market. However, this implication should not be drawn without paying due attention to the fact that only a part of the costs of export promotion are financed by assessments. Taking this into account, the evidence probably does not provide any basis for believing that promotional funds should be reallocated in either direction.

Alternative Interpretations

Consistently high estimated benefit-cost ratios for public investments in agricultural research across numerous studies have led many to conclude that, in spite of government intervention to correct the underinvestment that would arise from the unfettered workings of the free-market mechanism, too little is still being invested and further (or different) government action is warranted (e.g., see Alston and Pardey, 1996). In other words, the rationale for the collective action is private-sector underinvestment, owing to problems of free-riders and inappropriability of benefits from individual investments in R&D; by the same rationale, the benefit-cost ratios indicate that the action has not eliminated the market failure. Similar conclusions might be drawn from evidence of (remarkably) high benefit-cost ratios for promotion undertaken by a producer group. The reason for taking collective action is because it is believed the benefits will outweigh the costs. The high benefit-cost ratios could indicate that the collective action has not gone far enough; that the industry should be spending even more on its promotion program, and, given access to the information here, would.

This is not the only interpretation that can be placed on the evidence presented. Three alternative interpretations of a high measured benefit-cost ratios are possible, and they are not entirely mutually exclusive:

First, the benefit-cost ratio could be wrong. A high benefit-cost ratio might be estimated even though the true benefit-cost ratio would indicate no underinvestment (i.e., the true marginal benefit-cost ratio may be 1:1 or even less).

Second, alternatively, the benefit-cost ratio could be right but if those making the investment decisions do not believe the underlying estimates of response relationships, and do not believe the true ratio is greater than 1:1 at the margin, then they will not believe they are underinvesting and will continue to underinvest.

Third, the benefit-cost ratio could be right, and those making investment decisions could believe it to be true, and yet they would still continue to underinvest from the point of view of the industry, or society, as a whole. This outcome is a type of institutional failure. If the effective objective of the producer group is not simply to maximize benefits to the industry as a whole, but also to pay attention to differential patterns of benefits among different subgroups of producers, a persistent underinvestment is likely even when there is no uncertainty about the payoff to the industry as a whole.

In the context of high measured benefit-cost ratios for promotion undertaken by the California Table grape Commission, all three explanations may have something to contribute. Until now, formal estimates of the benefits and costs of the CTGC's promotion program have not been available. It may well be the case that, until now, the best estimate of the benefits relative to the costs would have been a conservative one, indicating no basis for believing in a substantial underinvestment in promotion. For some, that view will change as a result of the work reported here.

Nevertheless, it can be expected that our estimates will be viewed with skepticism by some readers. However, even the most skeptical reader would find it difficult to reach any conclusion, based on the data we have analyzed, other than that the benefits have well exceeded the costs. We have provided measures of precision of the benefit-cost ratio, and even the 99 percent lower bound is still an impressive benefit-cost ratio. In addition, our annual model results have been corroborated with results from monthly models and disaggregated models of individual cities. The export promotion investments seem to have been profitable, too. We cannot, and would not, rule out the possibility that our best point estimates overstate the true average and marginal benefit-cost ratios. However, we subjected the model to a number of tests for misspecification, and tried some alternative models, none of which changed our results much. Hence, we are confident that any reasonable reading of the information would lead to a view that the evidence indicates a high benefit-cost ratio and a persistent underinvestment. In Alston, et al. (forthcoming, 1997), we explore ranges of parameters to establish what one would have to believe about the demand response to promotion, the supply elasticity, or both to believe that the true benefit-cost ratio is 1:1.

We cannot rule out the third possibility: institutional failure. Tensions arise among individuals because they have different economic interests in the timing and form of promotion undertaken. Within any industry group, different producers produce different varieties, that reach different markets at different times. Consequently, not all producers benefit equally, or even equiproportionally, from any given promotional program -- even if it is strictly generic in nature. It can be expected that, in accommodating such tensions, those making investment decisions will be driven in the direction of devising programs with a more equal distribution of benefits, even though they may forego benefits in total. In addition, since, in large groups, the complete satisfaction of all members that their interests are being maximized is impossible, there will be a tendency to underinvest in total. Only if all producers had identical interests could this be avoided.

Conclusion

Our econometric results have provided strong evidence supporting the view that promotion by the California Table Grape Commission has significantly expanded the demand for California table grapes both domestically and in international markets. Using those results in a market simulation model, along with a range of assumed values for the elasticity of supply, we were able to compute estimates of benefits from promotion and compare them to the costs. The estimated benefits were many times greater than either the total costs, or the producer incidence of costs of a checkoff, even when we used very large assumed values for supply elasticities, which resulted in smaller estimates of producer benefits.

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