A New Framework for Evaluating Commodity Promotion Programs:

What Can We Learn from Disaggregate Data?

Hoy F. Carman
Email: carman@primal.ucdavis.edu

Lan Li
Email: lan@primal.ucdavis.edu

Richard J. Sexton*
Email: rich@primal.ucdavis.edu

Department of Agricultural and Resource Economics
University of California Davis
One Shield Avenue
Davis, CA 95616

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* Hoy F. Carman and Richard J. Sexton are professors, and Lan Li is a Ph.D. candidate in the Department of Agricultural and Resource Economics, University of California, Davis. This study was funded through a grant from the California Institute for the Study of Specialty Crops. The authors are grateful to the staff of the California Avocado Commission for providing generous access to their database.

1 Introduction

Many agricultural industries have utilized industry-wide promotion programs funded by producer and/or handler assessments as a tool to increase sales and producer incomes. Mandated commodity promotion programs are not only an important economic issue, but also a subject of dispute and litigation. Various studies have shown that these programs are often quite successful in generating a high return on the dollars invested (Kaiser et al. 2005). However, most of these studies have been conducted using aggregate time-series data, making it is difficult to identify the promotional effects precisely when many factors that can affect demand are changing together. Moreover, the evaluation at the industry level can provide little guidance in terms of targeting advertising to cities or retailers and determining which types of campaigns are most effective. This study evaluates industry-funded promotion programs for avocados, an important specialty commodity in California. We use a unique micro dataset that surmounts many of the problems incurred when working with aggregate data.

Promotions are a prospectively important tool to help the California avocado industry remain competitive in the face of increasing import competition. The industry has expended over $10 million annually for its marketing programs in recent years conducted through the auspices of the California Avocado Commission (CAC). In particular, the objectives of this study include (i) measuring the effects of the CAC's promotion programs by utilizing natural experiment design, panel models, and econometric techniques that isolate unobserved factors that may contribute to changes in demand, (ii) analyzing differential demand response to different types of advertising programs and cross different city markets, and (iii) developing a framework to estimate benefit-cost ratios at the city market level and discerning the benefit-cost ratios from the level of retail chain back to the farm gate. The evaluation for avocado promotion is also conducted by using aggregate time-series data and a typical benefit-cost analysis extended from Carman and Craft (1998). The results from both sets of evaluation are compared for discussions on what we have learned from use of novel data and models.

Mandated promotion programs will continue to be important and controversial. As retailer scanner data and other micro level data become increasingly available to researchers, this study opens discussion on new methodologies and more advanced models for promotion evaluation by utilizing novel data. Moreover, evaluating the effectiveness of the avocado industry's promotion programs will shed light on what strategies the California industry can undertake to remain competitive in face of increasing competition from imports. Although this study has a particular application for avocados, the results achieved and the methodologies developed will have broad implications for other agricultural industries and promotion programs.

2 California Avocado Industry and Its Promotion Programs

California avocados, with average annual sales of $346 million from 2001 to 2003, ranked fourth in farm value of production among California fruit crops (following grapes, strawberries, and oranges) and 16th among all California crop and livestock commodities (*California Agricultural Statistics*, 2003). California produces 90 percent of the annual U.S. avocado crop, with Florida accounting for the remainder (*Noncitrus Fruits and Nuts Summary*, 1997-2004).[1]

[1] Hawaii accounts for less than 0.5 percent of the U.S avocado annual production.

This study focuses on the Hass avocado variety, which is only produced in California in the U.S. The Hass variety accounts for about 92 percent of California avocado production and 97 percent of sales revenue for the five varieties with commercial production since 2001. Although produced throughout the year, production of California Hass avocados tends to be seasonal, with very low production during November and December, increasing to May and remaining high through September, and then decreasing through the end of October (see Figure 1).

Due to the seasonal pattern of California avocado production, avocado supply in the U.S. is supplemented by imports. The Hass variety has comprised 90 percent of total U.S. avocado imports since 2001. Chile is the largest avocado exporter to the U.S., followed by Mexico. The two countries account for over 90 percent of total avocado imports and virtually all of the Hass imports. As shown in Figure 1, avocado imports to the U.S. reveal a clear seasonal pattern that is counter to the seasonal pattern of the California avocado production. Imports of Chilean Hass avocados (CHA) occur throughout the year. CHA imports typically begin to increase in August, with the highest volumes occurring during September through December, and then decrease through March and remain very low until August.

Trade barriers for Hass avocados from Mexico have been in place due to stated concerns about invasive pests and diseases. There has been a progressive elimination of import restrictions on MHA since 1997. Avocado imports increased dramatically after the fourth quarter in 1998, while the domestic production fluctuated during this period (see Figure 1). The average annual growth rates were 35 percent for total avocado imports, 37 percent for Chilean avocado imports, and 55 percent for Mexican avocado imports during

1997—2004. The share of Chilean avocado imports remained stable, 66 percent on average during 1996—2004. The share of avocado imports emanating from Mexico increased from 7 percent in 1996 to 27 percent in 2004 accompanied by decreases in imports from other exporters, such as the Dominican Republic. Meanwhile avocado consumption has increased steadily during the same period, with an average annual growth rate of 10 percent. The share of domestic consumption supplied by California declined from 82 percent in 1996 to 55 percent in 2004.

Promotions are a prospectively important tool to help the California avocado industry remain competitive in the face of increasing import competition. The industry expended $10 million annually during 2002—2004 on its combined marketing programs conducted through the auspices of the California Avocado Commission (CAC). Specific marketing efforts have taken a variety of forms, including consumer advertising, merchandising, promotions directed to food service, and public relations. Consumer advertising received the greatest percentage of marketing program funds, averaging 50 percent of total marketing program expenditure during this period.

The CAC's advertising programs are conducted in eleven or twelve selected markets each year.[2] The selected markets for the CAC's promotions are those that did not have access to MHA imports. Further the promotion programs were conducted between March and August when MHA imports were not allowed and CHA imports were low. Therefore, the advertising programs are expected to have few spill-over effects that cause expansion in avocado imports.

[2] The selected markets for the CAC's promotion programs are Los Angeles, San Diego, San Francisco, Sacramento, Phoenix, Dallas, San Antonio, Houston, Denver, Portland, Seattle, and Atlanta. The CAC stopped its promotions in Denver after 2002, and began its promotions in Phoenix and Seattle in 2001.

The promotion programs are broken down into three categories by media type: radio advertising, outdoor displays, and magazine advertising.[3] Radio advertising received on average 61 percent of all advertising dollars during 2002—2004. Radio promotions are conducted four times for three-week periods between February and mid-July each year. Outdoor promotions are held during the intervals between radio promotions in all the selected markets except Atlanta, and involve displays of billboards and posters. Outdoor displays accounted for 21 percent of the advertising expenditure for the same period. Magazine advertising has taken place only in Atlanta, which is considered as a developing market by the CAC. Information cards and/or flyers are placed in some issues of some magazines sold in Atlanta.

3 Analytical Model for Promotion Evaluation

The impact of advertising programs on demand at the retail level is illustrated in Figure 2. Several economic bases and empirical evidence support the hypothesis that grocery retailers are likely to posses some degree of market power in selling into consumers. In practice, large retail chains make pricing decisions collectively. Hence, we assume retail chains face a downward-sloping demand for avocados, which is d_0 in absence of advertising programs. If advertising programs are successful in promoting demand at the retail level, the demand curve shifts to the right to d_1. Retail chains' supply for avocados is represented as s. The quantity and price of avocados in the initial equilibrium without promotions are q_0 and p_0.

Because avocado is a perennial crop, the short-run supply is expected to be perfectly inelastic. Shipments need to be relocated between markets where promotions

[3] Eighty-five percent of consumer advertising funds were spent on radio advertising, outdoor displays, and magazine advertising during 2002—2004. The rest were used to cover administration costs (8.6%), and were spent on other programs (6.4%), such as coupon program.

are conducted and markets where promotions are not implemented, in order to accommodate increases in demand in promotion markets. Figure 3 illustrates the arbitrage of avocado shipments between markets with promotions and without promotions, given that a demand shift is generated in promotion markets. The shipping price in promotion markets increases as a result of demand shift, and the shipping price in markets without promotions rises due to the decrease in shipment. Shipments to promotion markets continue to increase until shipping prices in both markets with promotions and without promotions equal to each other. All in all, shipping price increases as a result of the demand shift generated by industry promotion programs.

Increase in the shipping price raises retailers' purchasing price for avocados. If retail price for avocados increases only in an amount of the increase in the shipping price, retail margin maintains unchanged. Consequently, the demand shifts to the right to q_1 and price increases to p_1.

Warner and Barsky (1995) and Chevalier, Kashyap, and Rossi (2003) showed that retail prices revealed countercyclical movements over demand cycles for many consumer products and supermarket commodities, respectively. Li, Carman, and Sexton (2005) found that retail prices and margins are significantly lower during demand peaks for avocados. Both Chevalier, Kashyap, and Rossi (2003) and Li, Carman, and Sexton (2005) support the hypothesis of Lal and Matutes' (1994) model. Lal and Matutes (1994) developed a model to explore retailers' pricing and advertising activities. In their model, retailers compete with each other conducting advertised sales in order to attract consumers into the store and earn profit from other goods that consumers buy if they visit the store. The implication of their model is that retailers are more likely to put products with high demand on sale. If retailers choose to lower retail margins in response to industry promotions either by lowering retail price or by maintaining retail price unchanged given the shipping price for avocados has increased, we expect demand for avocados at the retail level expands further to q_2 or q_3.

On the other hand, evidence of higher retail markup, i.e., by which retail price is higher than p_1, in response to the CAC promotions supports a simple market power model of retail pricing, whereby retailers increase prices and margins to capture benefits from the demand expansion. Notably the behavior described in Lal and Matutes' model reinforces the effect of the CAC promotions, while behavior describe by the simple market power model mitigates their effectiveness.

The effects of promotion programs at the farm level are illustrated in Figure 4. Because avocado is a perennial crop, plantation decisions are predetermined. Therefore, the avocado supply (S) is fixed at Q_0. Demand for avocado at the aggregate level is represented as D_0. P_0 is the price for avocados at the farm level in the initial equilibrium without promotions. If industry promotions are successful in increase demand, demand curve shifts from D_0 to D_1. Farm price increases from P_0 to P_1 as the result of the positive demand shifts generated by promotions. The increase in farm price equals to the increase in shipping prices shown in Figure 3, because growers/shippers are integrated in avocado market.

The benefit of promotions can be represented as the rectangular area $P_0P_1E_1E_0$. There are two ways to estimate the benefit: We can obtain the changes in farm-level price by estimating an inverse demand model at the farm gate and calculate the benefit of promotions given a fixed production volume. The other way is to estimate demand shifts at the retail market and derive changes in farm-level price from the demand shift. If the demand shift, Q_0Q_1 in Figure 4, can be measured and the slope coefficient of the aggregate demand curve can be estimated, the change in farm-level price can be derived.

A new framework for promotion evaluation is developed in this paper to measure the benefit of promotions at the retail and city market level and retrieve the benefit from the city market level back to the farm gate. First we describe the framework in the case that the data on promotion expenditures are only available at the aggregate level, e.g., the total amount that the CAC spent on promotion programs in 2003. The discussion on the disaggregated measurements for promotion benefits and benefit-cost ratios follows.

In the first step, we estimate a demand model for avocados at the retail level, where promotion is captured as a demand shift factor in the model. Therefore, the demand shift in each promotion market can be estimated. Then, demand expansions due to promotions in all promotion markets are aggregated. Third, we estimate an inverse demand model at the farm gate to obtain the slope coefficient.

Fourth, based on the estimated slope coefficient of the inverse demand model and the estimated demand shift, we simulate the effects of demand expansion on farm-gate price. Notice that not only can we obtain the change in farm price due to the total demand shift, but also we can simulate the changes in farm price due to demand shift in a particular market. Fifth, the benefit of promotion as the rectangular area, $P_0P_1E_1E_0$ in Figure 4, is calculated. Finally, the average benefit-cost ratios can be obtained based on the information on promotion expenditure.

More valuable analysis on the effectiveness of promotion programs can be achieved, if the data on promotion expenditure are available at the city market level, and/or by promotion types (e.g. radio or outdoor promotions), and/or in specific time periods. Both average and marginal benefit-cost ratios can be estimated at the market level, by promotion types, and by the times of promotions. For example, the increase in farm-gate price due to demand shifts generated by radio promotions in Los Angeles can be estimated and the corresponding marginal and average benefit-cost ratios can be calculated.

Various studies estimated demand expansion and benefits of industry promotion programs by utilizing time series data at the aggregate level. The only prior evaluation of avocado industry advertising programs is the work of Carman and Craft (1998), who analyze the CAC's promotion programs using aggregate annual data from 1961-95. The changes in farm-gate price are obtained by estimating an inverse demand model at the farm gate that incorporates industry promotion as a demand shift factor. The benefit is calculated based on the estimated price change and the production volume. The study indicates that avocado advertising was effective on balance, yielding an average return of $7 per $1 expended on advertising. However, it does not provide evidence on demand responses to different promotion activities at the disaggregated level. In addition, little is known about how retailers' pricing strategies interact with and modify the effectiveness of this and other industry promotion programs. The data set available for this study provides us an unprecedented opportunity to assess these issues.

The framework developed by this paper has the following advantages: i) a "cleaner" identification of promotional effects can be achieved by a natural experiment design and by utilizing retail and city market level data, so that unobserved factors that may contribute to changes in demand are isolated; ii) different types of advertising programs, across different city markets, and during different times of the year can be evaluated; iii) the role of retailer pricing strategies in industry promotions can be analyzed.

4 The Data

We were able to assemble a unique and comprehensive data set through the cooperation of the CAC and its marketing agent—Fusion Marketing. The specific data sources include weekly retailer scanner data provided by Information Resources Inc. (IRI) for 82 major U.S. retail accounts across 38 markets for avocados from November 2001 to October 2004. A "retail account" refers to a particular market-retail chain combination, e.g., Retailer 1 in Chicago. There are 46 retail chains in the data. We are not able to reveal the names of retail chains due to the agreement with IRI. The weekly data include volume and dollar sales, and retail prices. We focus on large and small sizes of Hass avocados, which were carried by most of the retail accounts and accounted for over 90 percent of the total category sales. Marketing year for avocados instead of calendar year is used in our analysis. A marketing year runs from Mid-October through Mid-October in the following calendar year.

Second, the CAC provided weekly shipment data, including shipping-point prices and shipment volumes of Hass avocados from California to each of the 38 destination markets during the study period. The weekly shipping-point prices are the average weekly prices charged by shippers for shipments to each of the destination markets. These prices exceed the farm-gate prices by amounts that reflect shippers' inventory and transactions costs and provide a better reflection of what retailers in each destination market actually paid than do the farm-gate prices. Third, the commission publishes monthly farm prices and volumes for varieties of Californian avocados. Fourth, we obtained data on monthly volumes and values of total Hass imports to the U.S., and the Hass imports from Chile and Mexico to the U.S. from the United States International Trade Commission (USITC).

Finally, we were provided access to information on the media types, geographic locations, and the timing of the advertising programs conducted by the CAC during the study period. For example, a radio promotion was conducted in all promotion market in the first three weeks of March 2003, and a print promotion was conducted in Atlanta in May 2003. Further, the data on the annual expenditure for each type of promotions is utilized when we conducted this analysis.

5 Empirical Methodology—the Approach of "Difference-in-Difference"

The approach of Difference in Difference (DID) is employed to evaluate the promotional effects of the CAC's advertising programs on retail sales, and to examine how retailers set prices in response to the CAC's promotions. The DID approach has been applied broadly in studies on program and policy evaluations, such as Card's (1990) assessment of the effects of immigration on native wages and employment and Angrist and Levy's (1999) analysis of the effect of class size on student test scores. Despite substantial prior research on evaluation of promotion programs, few have utilized the DID approach. To our knowledge, the only study is Busse, Silva-Risso, and Zettelmeyer (2004), who analyze the effects of asymmetry information in the bargaining process on transaction prices under cash rebate promotions in the car industry.

We discuss the DID approach in the context of evaluating the effect of the CAC's promotion programs on retail sales following Ashenfelter and Card (1985), who evaluate the effect of job training on earnings. The DID approach is also applied to evaluate other outcome measures, such as retail prices and margins. The empirical models for each of the outcomes are presented in the next section.

The fact that the CAC selected a set of markets for its promotion programs enables us to construct both treatment and control groups for the program evaluation. The DID approach estimates the counterfactual outcomes for the retail accounts in the selected markets that received the CAC's promotion programs. The DID framework for identifying the "treatment effects" of the CAC's promotions on retail sales can be presented by the following linear model:

$$q(a,t) = \delta(t) + \eta(a) + \psi D(a,t) + \beta p(a,t) + \nu(a,t), \quad (1)$$

where $q(a,t)$ denotes retail sales (or demand) for avocados at retail account a and time t. Let the pre-treatment period, $t = 0$, be the period when there was no promotion, and let the post-treatment period, $t = 1$, be the period when the CAC conducted its promotions. $D(a,t)$ denotes whether a retail account was exposed to the CAC's promotions or not. $p(a,t)$ denotes the retail price of avocados sold by retail account a at time t. Suppose that only $q(a,t)$, $D(a,t)$ and $p(a,t)$ are observed. We refer retail accounts that were exposed to the CAC's promotion programs (i.e., $D(a,1) = 1$) as the "treated", and those that were not exposed to the promotions (i.e., $D(a,1) = 0$) as the "controls". $D(a,0)$ equals zero for both the treated and controls, because there was no promotion at $t = 0$. ψ represents the "treatment effects" of the CAC's promotion programs. $\delta(t)$ denotes the time-specific component, $\eta(a)$ represents the account-specific effects, and $\nu(a,t)$ is the individual transitory error term with zero mean at both $t = 0$ and $t = 1$. The advantage of the panel data utilized in this study enables us to control idiosyncratic characteristics of individual retailers or markets by fixed effects.

The CAC did not select markets for its promotion programs randomly. The selected markets are among the top fifteen markets that have the largest market shares of avocado sales in the U.S., and did not allow MHA imports during the study period.[4] A concern usually arises about selection bias. That is, selection for promotions may be correlated with the individual transitory error term. However, the set of markets selected by the CAC for promotion has been quite stable since 1997. We believe that market selection for the CAC's promotions is affected by market-specific characteristics that do not change during the study period, and, therefore, can be controlled by fixed effects.

Under the assumption that selection for treatment is not correlated with the error term, we can obtain the difference in the expected retail sales with and without the CAC's promotions for the retail accounts in the treated and control markets as

$$\begin{aligned} & E[q(a,1) \mid D(a,1)=1] - E[q(a,0) \mid D(a,1)=1] \\ &= E[q(a,1) - q(a,0) \mid D(a,1)=1] \\ &= [\delta(1) - \delta(0)] + [\eta(a) - \eta(a)] + \psi[D(a,1) - D(a,0)] \\ &\quad + E[p(a,1) - p(a,0) \mid D(a,1)=1] \\ &= \delta(1) - \delta(0) + \psi + \beta E[p(a,1) - p(a,0) \mid D(a,1)=1] \end{aligned}$$

$$\begin{aligned} & E[q(a,1) \mid D(a,1)=0] - E[q(a,0) \mid D(a,1)=0] \\ &= E[q(a,1) - q(a,0) \mid D(a,1)=0] \\ &= [\delta(1) - \delta(0)] + [\eta(a) - \eta(a)] + E[p(a,1) - p(a,0) \mid D(a,1)=0] \\ &= \delta(1) - \delta(0) + \beta E[p(a,1) - p(a,0) \mid D(a,1)=0] \end{aligned}$$

[4] An exception is Denver, where the CAC continued promoting avocados in 2002 after MHA imports were allowed to enter Colorado in November 2001, but the CAC discontinued its promotion programs in Denver after 2002.

Notice that the use of a simple comparison of retail sales before and after promotions to evaluate the promotional effects is likely to be biased by temporal trends in retail sales or by factors other than the promotions that occurred during both periods. The DID approach is applied to construct a counterfactual against which to measure the promotional effects. Therefore, the "treatment effects" of the CAC's promotions can be identified in the following form:

$$\begin{aligned}&\{E[p(a,1) \mid D(a,1)=1]-E[p(a,0) \mid D(a,1)=1]\}\\&-\{E[p(a,1) \mid D(a,1)=0]-E[p(a,0) \mid D(a,1)=0]\}\\&=\psi+\beta\{E[p(a,1)-p(a,0) \mid D(a,1)=1]-E[p(a,1)-p(a,0) \mid D(a,1)=1]\}\end{aligned}$$

The effects of promotion programs can be decomposed into two parts. One is represented ψ by that is the demand shift generated by promotions and is presented as q0q1 in Figure 2. The other is the changes in demand due to changes in retail price as the result that retailers adjust retail prices for avocados in response to industry promotions. We now turn to discuss the effects of promotion programs on retail prices.

The DID estimator requires a strong assumption that the average outcomes for the treated and controls would have followed parallel paths over time in the absence of the treatment. However, a complication arises in our application because shipping-point prices for avocados differ somewhat across market destinations, as table 1 documents. Further, it is possible that shipping-point prices moved differently in promotion market from those in the markets without promotions. If retail prices at the stores in the treated markets were higher than retail prices at the stores in the control markets, it could be the result of the higher shipping-point prices in the treated markets relative to the control markets. Therefore, we incorporate the contemporaneous and lagged market-specific shipping-point prices as explanatory variables to control for the difference in shipping-point prices between the treated and control markets.

The other complication is that different markets might have different supply sources of Hass avocados other than California. Each of the markets selected for the CAC's advertising programs is in a state that did not allow MHA imports during the study period. However, many markets in the control group in our data had access to MHA imports. The markets that allowed MHA imports likely had lower avocado acquisition costs during the months that MHA were available.[5] Therefore, retail prices in the treated markets could be higher than retail prices in the control markets during some periods of the CAC's promotions because of relatively higher avocado acquisition costs in the treated markets. However, this problem is less worrisome, because only at the beginning of the promotion period, i.e. in March, MHA imports were allowed.

We tackle this problem in two ways. First, we construct two different control groups. One control group includes markets that did not have access to MHA imports, and the other includes both markets that allowed and did not allow MHA imports. Second, we incorporate import volumes of MHA into the model when the control group includes both markets with and without access to MHA imports.

The DID model for retail prices takes the following form that incorporates the shipping-point prices of California avocados and the Hass avocado imports from Mexico and Chile as covariates:

[5] To get a sense of the price difference between domestic and imported avocados, we calculated the per lb. costs of avocados imported from Chile and Mexico as the landed duty-paid values of the imports divided by import volumes. This measure includes essentially all costs incurred in getting the imported product across the border and is comparable to a per lb. shipping-point price from California. The following are the summary statistics for mean price/lb. over our November 2001—October 2004 sample period: Mexican imports—$1.0061 (s.d. = 0.065), Chilean imports—$1.0781 (s.d. = 0.0210), California—$1.1668 (s.d. = 0.2453). Thus, Mexican (Chilean) imported avocados were about $0.17/lb. ($0.09/lb.) cheaper on average relative to California avocados.

(2) $p(a,t) = a(t) + b(a) + cD(a,t) + dw(a,t) + eimpMH(a,t) + fimpCH(t) + \zeta(a,t)$,

where *w(a,t)* denotes the California shipping-point price at time *t* in the market where the retail account *a* is located; *impMH(a,t)* represents MHA import volumes that are relevant to retail accounts in the states that allowed MHA imports at time *t*; and *impCH(t)* are import volumes of CHA at time *t* that are common to all the markets. In this generalized model, *c* is no longer the only term that accounts for the difference in the expected retail prices with and without promotions, and between accounts in the selected markets and control markets. However, *c* can still be identified as the "treatment effect" of the CAC's promotion programs on retail prices. That is,

$$
\begin{aligned}
& \{E[p(a,1) \mid D(a,1)=1] - E[p(a,0) \mid D(a,1)=1]\} \\
& - \{E[p(a,1) \mid D(a,1)=0] - E[p(a,0) \mid D(a,1)=0]\} \\
= \quad & c \\
& + d\{[w(a,1) - w(a,0) \mid D(a,1)=1] - [w(a,1) - w(a,0) \mid D(a,1)=0]\} \\
& + e[impMH(a,1) - impMH(a,0) \mid D(a,1)=0]
\end{aligned}
$$

If *c* is zero, we expect that retailers only adjust retail prices in response to changes in shipping-point price or prices for imported avocados due to promotional activities.

We return to the discussion on the promotional effects on retail sales. If retail margins do not change in response to industry promotion programs, we expect that ψ represents the demand expansion generated by promotion programs at the retail level. Otherwise, the total demand expansion at the retail level is the sum of demand shift generated by promotions and the demand increase due to retailers' pricing strategies.

The above framework is applied to evaluate three types of the CAC's promotions—radio, outdoor, and magazine advertising programs. However, the promotional effects of magazine advertisements might not be clearly identified. The DID approach requires unambiguous recognition of the periods with and without promotions.

However, the timing that people are exposed to magazine advertisements is highly uncertain. For example, people could purchase an issue of a monthly magazine at any time of the month, and read it at any time after that month. In any event, magazine advertisements are of minor importance to our analysis, given that they were conducted only in Atlanta.

In contrast, the promotional effects of both radio and outdoor programs can be identified under the DID framework. People could either be exposed to an advertisement directly at the same time, or obtain the information about the advertisement indirectly through other people. Since each radio or outdoor promotion lasted a fair amount of time, three or four weeks respectively, we expect that both radio and outdoor advertising programs generated promotional effects, if any, mostly during the promotion periods. A concern still rises about identifying possibly lagged effects of both radio and outdoor promotions. Because radio and outdoor promotions followed each other consecutively, the promotional coefficient of radio advertising could also pick up the lagged effects of the preceding outdoor promotions, and vice versa. The data give us no good way to discriminate between these possibilities, but, notably, if the primary focus is the overall effectiveness of the CAC's synchronized radio-and-outdoor-media campaign, separating the impacts of the individual components is unimportant.

6 The Empirical Model

We evaluate the effects of the CAC's promotion programs on both retail sales and retail pricing. In particular, three empirical models are estimated: a retail sales model, a model of retail prices, and a model of retail margins. In the following, we present empirical models for retail sales and retailer pricing behavior along with discussions on variable selection, estimation methods, and hypothesis tests.

A retail sales model

A retail sales response model is estimated to examine the effectiveness of the CAC's advertising programs in terms of promoting demand at the retail level. The retail sales model is specified in the following form:

$$
\begin{aligned}
q_{a,s,t} &= \gamma + \gamma_t + \gamma_{a,s} \\
&\quad + [\beta_1 \hat{p}_{a,s,t} + \beta_2 \hat{p}_{a,s,t-1}] \\
&\quad + [\tau_1 Radop_{m,t} + \tau_2 Outdoor_{m,t} + \tau_3 Magazine_{m,t}] \\
&\quad + \varepsilon_{a,s,t}
\end{aligned}
\tag{1}
$$

where $q_{a,s,t}$ is the sales volume for size *s* avocados at retail account *a* in week *t* in 1000 units. $\hat{p}_{a,s,t}$ and $\hat{p}_{a,s,t-1}$ are the predicted retail prices for size *s* at account *a* in week *t* and *t*-1 obtained from the estimation of the retail pricing model that will be discussed in the following. Due to the likely endogeneity between the retail prices and the error term in the sales response model, we include the predicted retail prices instead of the actual retail prices.

γ is the constant term. γ_t represents time-related control variables, which account for demand variation over (i) marketing years, (ii) months, and (iii) holidays or special events. A marketing year runs from Mid-October to Mid-October the next calendar year. Fixed effects, $\gamma_{a,s}$, are utilized for particular account-size combinations to control for different seasonal demand patterns across different retail accounts.

The set of terms in the second brackets measure the impacts of the CAC's promotion programs. $Radio_{m,t}$, $Outdoor_{m,t}$, and $Magazine_{m,t}$ are the "treatment on the treated" variables, which are set equal to one if the CAC was running a radio, outdoor, or magazine promotion program in market m in week t. τ_1, τ_2, and τ_3 are the coefficients to be estimated that represent the "treatment effects" of the CAC's radio, outdoor and magazine advertising programs on retail sales, respectively.

The γ s, βs, and τs, are the parameters to be estimated. The error term, $\varepsilon_{a,s,t}$, is specified as

$$
\begin{aligned}
&\varepsilon_{a,s,t} \sim N(0,\Omega) \\
&Var(\varepsilon_{a,s,t}) = \delta^2_{a,s} \\
&Cov(\varepsilon_{a,s,t}, \varepsilon_{-a,-s,t}) \neq 0 \\
&\varepsilon_{a,s,t} = \rho_{a,s}\varepsilon_{a,s,t-1} + \upsilon_{a,s,t}
\end{aligned}
$$

The error term is assumed to have a normal distribution with zero mean and heteroskedastic variances for each of the account-size combinations. Second, the errors are assumed to be contemporaneously correlated between any account-size combinations. Furthermore, the error term is also assumed to follow an AR(1) process, and different autocorrelation parameters are allowed for different account-size combinations. $v_{a,s,t}$ is white noise. The model is estimated by the Prais-Winsten method, which utilizes a feasible generalized least squares estimation procedure conditioning on the assumed error structure.

The model is estimated by a two-stage least squares procedure. At the first stage, the retail pricing model is estimated by the Prais-Winsten method, and the predicted retail prices are obtained. At the second stage, the retail sales model is estimated by the Prais-Winsten procedure by incorporating the predicted retail prices from the first stage.

A Retail Pricing Model

A retail pricing model is applied to capture retail price movements in response to changes in cost and demand factors. Based upon equation (2), the retail pricing model is specified in the following form:

$$
\begin{aligned}
p_{a,s,t} &= \alpha + \alpha_t + \alpha_{a,s} \\
&+ [\psi_1 Radio_{m,t} + \psi_2 Outdoor_{m,t} + \psi_3 Magazine_{m,t}] \\
&+ [\theta_0 w_{m,s,t} + \theta_1 w_{m,s,t-1}] \\
&+ [\lambda_1 Season_t + \lambda_2 impMH_{m,t} + \lambda_3 impMH_{m,t-1}] + [\lambda_4 impCH_t + \lambda_5 impCH_{t-1}] \\
&+ \varepsilon_{a,s,t}
\end{aligned} \tag{2}
$$

where $p_{a,s,t}$ is the retail price measured by \$/unit at retail account a for size s (s = {large, small}) in week t. The time-related control variables, fixed effects, and the variables for the CAC's promotion programs have the same interpretations as those included in the retail sales model. Fixed effects, $\alpha_{a,s}$, are utilized for particular account-size combinations to control for heterogeneity in retailer pricing behavior. ψ_1, ψ_2, and ψ_3 are the coefficients to be estimated that represent the "treatment effects" of the CAC's radio, outdoor and magazine advertising programs on retail prices, respectively.

$w_{m,s,t}$ and $w_{m,s,t-1}$ in the second set of brackets are the shipping-point prices measured by \$/unit for size s avocados shipped from California to market m in week t and t-1. The shipping-point price and its one-week lag account for the impact of contemporaneous and lagged cost-side shocks on retailers' prices. A two-week period should represent a sufficient time period for changes in the shipping-point price for this highly perishable commodity to reflect fully in retailers' acquisition costs (see footnote 8).

The third and fourth sets of brackets contain terms for MHA and CHA imports, respectively. $Season_t$ captures the common seasonal shocks for all the markets during the period when MHA imports were available, and it is set equal to one if MHA imports were allowed in week *t*. The variables $impMH_{m,t}$ and $impMH_{m,t-1}$ are MHA import volumes in 1,000,000 pounds in the current month and previous month, respectively. The import volumes of MHA are the total MHA imports to the U.S., but not market specific. The subscript *m* only indicates whether import volumes of MHA are relevant to market *m* that allowed MHA imports in week t. $impMH_{m,t}$ and $impMH_{m,t-1}$, therefore, represent the "treatment on the treated". The variables $impCH_t$, and $impCH_{t-1}$ in the fourth set of brackets have the same interpretation but apply to import volumes of CHA, which are relevant to all markets. All the import volumes are on a monthly basis. They represent the import volumes of MHA or CHA available in the month in which week *t* is located. Because the storage life expectancy is less than two weeks (see footnote 8), the lagged import volumes were constructed so that import volumes in the last month are only relevant to the time prior to the middle of the current month.

The error term, $e_{a,s,t}$, is assumed to have the same structure as the error term in the retail pricing model.

A model of the farm-retail price spreads

The retail pricing model, however, cannot directly reflect how retail markups change over demand shocks. Therefore, we construct the farm-retail price spread as an approximation to the retail margin, and estimate a model of the farm-retail price spread. The dependent variable is the farm-retail price spread in $/unit for size *s* avocados at account *a* in week *t*. It is computed as the difference between retail price for size *s* avocados at retail account *a* in week *t* and the shipping-point price for size *s* avocados shipped from California to market *m* in week *t*.

There were cases when California Hass avocados were not shipped to some market during some period. If a market was not supplied by California for one or two weeks, we use the average of shipping-point prices of the preceding and following weeks when the shipping-point prices were available. If a market was not supplied by California for more than two weeks, we use shipping-point prices in a market located closest or the average of shipping-point prices in several markets located close. In either case, the proxy shipping-point price is the shadow price of California Hass avocados that retailers in the market utilized to make their procurement decisions.

The model includes all explanatory variables in the retail pricing model with exclusion of shipping-point prices. Furthermore, we include shipment volumes as an explanatory variable, which are shipments in 1,000,000 units for size *s* avocados shipped from California to market *m* in week *t*. The variable is included to indicate whether retailers are able to bid down shipping-point prices for avocados as a consequence of large shipments.[6] The model is assumed to have the same model and error structure as the retail pricing model. It is also estimated by the Prais-Winsten method.

Consider now the expected effects of the CAC's promotions on retail sales, retail prices and markups. If the promotions are successful, retail sales should rise, whereas unsuccessful promotions will have little impact on sales. A priori expectations for the impact of promotions on retail prices are less clear. Unsuccessful promotions should have little impact on retailer pricing behavior. Lal and Matutes' model (1994) implies that retail prices or markups should fall during the CAC's promotion periods, given that the promotions are successful in increasing demand. In contrast, Warner and Barsky's model

[6] This hypothesis was proposed and tested for iceberg lettuce by Sexton and Zhang (1996) and subjected to further testing by SZC (2003) for iceberg lettuce and fresh tomatoes.

(1995) does not predict that retailers reduce retail prices or margins as a result of the increase in avocado demand generated by the CAC's promotions. On the other hand, evidence of higher retail markups in response to CAC promotions supports a simple market power model of retail pricing, whereby retailers increase prices and margins to capture benefits from the demand expansion. Notably the behavior described in Lal and Matutes' model reinforces the effect of the CAC promotions, while behavior described by the simple market power model mitigates their effectiveness.

In reality, retailers usually arrange advertised sales before the acknowledged demand shocks. As commonly observed, store flyers that contain advertised sales are usually circulated a week before sales actually take place. For example, retailers learn from experience or perceive a higher consumption of avocados during certain periods or holidays. Retailers, according to Lal and Matutes (1994), will lower retail prices or markups correspondingly. Two implicit conditions are that (i) retailers are well informed about the demand shock, and (ii) retailers perceive the demand shock is positive. A lack of response in retail pricing to the demand shocks generated by the CAC's promotions does not necessarily imply that retailers behave competitively. It might be caused by lack of communication between the industry and retailers about the industry's advertising campaigns and the effectiveness of the advertising programs.

We can also test whether the effects of the CAC's promotion programs on retail prices and sales are different across markets by estimating the models separately to obtain the pooled promotion parameters across all of the CAC treated markets and the market-specific promotion parameters in each of the treated markets. Differences among cities in the sales response to promotions may reflect different levels of intensity of promotion by the CAC, or it may reflect markets that, for whatever reason, are more or less susceptible to avocado promotions. Such information can be valuable to CAC in tailoring its programs.

7 The Results

Table 4 presents the estimation results for the effects of the CAC's promotion programs. The CAC's radio and outdoor advertising campaigns were associated with significantly higher retail demands in the base model. The presence of the radio (outdoor) campaign in the treated market was associated on average with 7,058 (8,822) more units sold for each size of Hass avocados at a retail account in one week. Magazine advertising in Atlanta had a positive but mild and insignificant coefficient. Neither the radio, nor outdoor, nor magazine campaigns had a significant impact on retail price, or on retail markup on average. Retail price and markup were lower (higher) during the radio (outdoor) campaigns, but the effect was negligible and insignificant. Lower retail price and markup during the radio promotions may suggest that retailers responded more actively to the radio advertising than to the outdoor promotions.

Market-specific promotion coefficients are also estimated for the CAC's radio and outdoor campaigns. The estimation results are reported in Table 5.[7] Nine of the ten selected markets were associated with higher retail sales during the radio promotions, and with three of them (San Francisco, Los Angeles and Dallas) had significantly higher sales. A test for equality of the sales responses to the radio campaigns is rejected at the 95 percent level (χ^2_9=17.08, ρ = 0.048). None of the three markets with significantly higher

[7] Table 9 only reports coefficients related to the market-specific effects. Coefficients for the other variables were little changed when the estimation model was expanded to include market-specific effects for the promotion variables.

sales during the radio promotions were associated with significantly lower retail prices or markups. Retail prices were lower in five out of ten treated markets, but only significantly lower in Atlanta, during the radio promotions. A test that the price responses to the radio promotions are jointly equal to zero in all treated markets is rejected at the 95 percent level (χ^2_9=19.95, ρ = 0.032). Radio promotions had no significant effects on retail markups in any of the treated markets. A test that the responses of retail margins to the radio campaigns are jointly equal to zeros in all treated markets cannot be rejected (χ^2_9=13.04, ρ = 0.221).

The estimates of the market-specific responses to the CAC's outdoor campaigns revealed a higher degree of heterogeneity than those to the radio campaigns. All of the three tests for equality of the responses in sales, retail prices, and retail markups to the outdoor promotions across the treated markets are rejected. Eight out of nine markets had higher retail sales during the outdoor promotions, with four of the effects being statistically significant. The CAC's outdoor campaigns had the strongest sales effects in San Antonio, where retail prices and markups were also significantly lower during the outdoor campaigns. Notice that the radio campaigns also had the largest positive effects on sales, and negative effects on retail prices and retail markups in San Antonio, although none of them are statistically significant. Combined, the CAC's radio and outdoor campaigns had comparatively large effects on retail sales in San Antonio, San Francisco, and Los Angeles, and comparatively minor effects on retail sales in Portland and Atlanta.

Both radio and outdoor advertising programs were successful in promoting sales at the retail level in the selected markets. In general, both campaigns had little effect on retail prices and retail margins. On balance the evidence is mixed relative to the Lal and

Matutes hypothesis that higher retail demands are associated with lower retail prices or retail margins, and there is no support for the market-power hypothesis that retailers would capture benefits of demand-expanding industry promotions through charging higher prices.

As noted, retailers usually make ex-ante pricing decision. Retailers, according to Lal and Matutes, reduce retail prices or retail markups only if they are well informed about the advertising campaigns, and/or they believe that the CAC's radio and outdoor promotions will effectively increase avocado demand. Therefore, the CAC's promotion programs could possibly be enhanced if the CAC improves communication with retailers about its advertising campaigns.

Further, we calculate the average benefit-cost ratio of the CAC's promotion program. First, we aggregate the demand shift at the retail level for each market and aggregate the demand shift for each week during promotion period on average to each year. Further, we convert the demand shift from units to pounds according to the size and packing information provided by the industry. We utilize the estimated price elasticity at the farm-gate level, -1.33, by Carman and Craft (1988) as a starting point of the preliminary analysis. The demand expansion is 3783604 pounds each year on average during 2002-2004 for the selected retail chains in the promotion markets. This demand expansion causes the farm-gate price to increase by 1.39% on average. Since we are waiting for the last set of data on the percentage of retail sales of selected retail chains in a certain market and the percentage of retail sales in selected market in a certain shipping area, we cannot draw the final conclusion on the benefit cost ratios.

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Figure 1 Californian Avocado Production and Avocado Imports to the U.S.

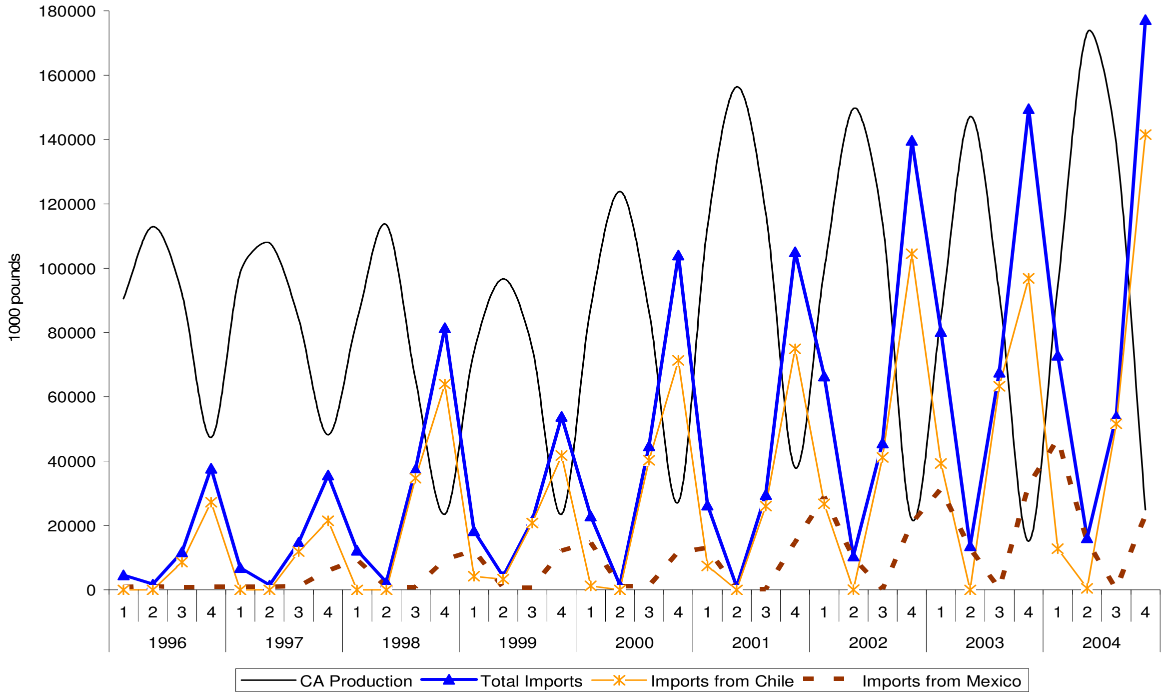

Figure 2 The effects of Promotion Programs at the Retail Level

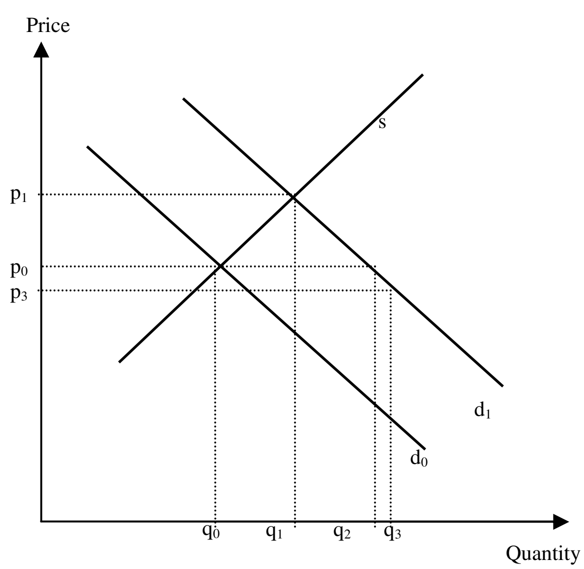

Figure 3 The effects of Arbitrage between Markets with and without Promotions

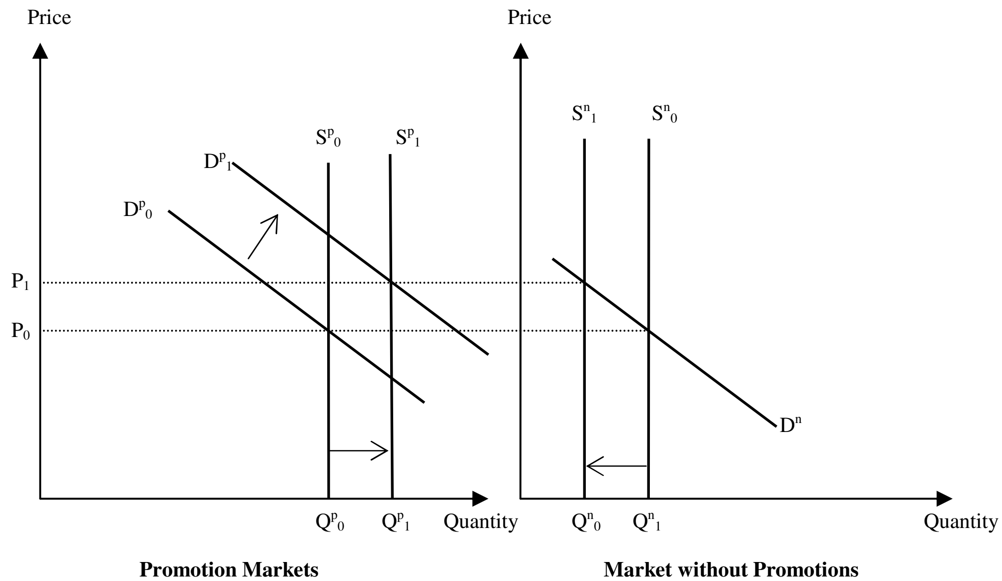

Figure 4 The effects of Promotion Programs at the Farm Gate Level

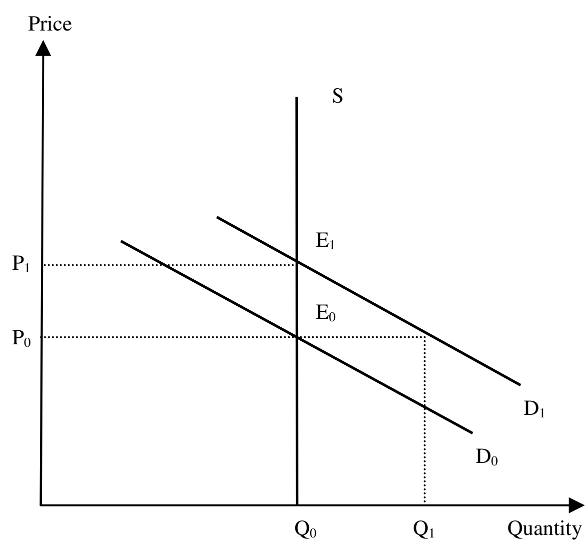

Table 1: Estimation Results for Retail Sales Model

Dependent variable	Retail Sales
Constant	65.084***
	(13.183)
Retail price	
Retail price (t)	-58.128***
	(14.175)
Retail price (t-1)	-7.066
	(9.649)
Promotions	
Radio	7.058***
	(2.857)
Outdoor	8.822***
	(3.376)
Magazine	0.430
	(2.076)
R-squared	0.72

Notes:

1. Standard errors are reported in the parentheses.
2. One, two, and three asterisks indicate statistical significance at the 90%, 95%, and 99% level, respectively.

Table 2: Estimation Results for Retail Pricing Model

	Estimated Coefficient
Constant	1.206*** (0.110)
Shipping point price	
Shipping point price (t)	0.136*** (0.027)
Shipping point price (t-1)	0.205*** (0.027)
Imports	
Mexican imports (t)	0.002 (0.002)
Mexican imports (t-1)	-0.006*** (0.002)
Chilean imports (t)	-0.002** (0.001)
Chilean imports (t-1)	-0.003*** (0.001)
Promotions	
Radio	-0.007 (0.012)
Outdoor	0.010 (0.014)
Magazine	0.022 (0.032)
R^2	0.69

Notes: The same as those listed in table 1.

Table 3: Estimation Results for Farm-Retail Spread Model

Dependent variable	The Farm-Retail Price Spread
Constant	0.786*** (0.091)
Shipment volume	0.038*** (0.009)
Imports	
Mexican imports (t)	0.001 (0.002)
Mexican imports (t-1)	-0.007*** (0.002)
Chilean imports (t)	-0.002 (0.001)
Chilean imports (t-1)	-0.003** (0.001)
Promotions	
Radio	-0.005 (0.013)
Outdoor	0.014 (0.014)
Magazine	0.021 (0.032)
R-squared	0.42

Notes: The same as those listed in table 1.

Table 4: Effects of the CAC's Promotions

	Retail Sales	Retail Price	Price Spread
Radio	7.058***	-0.007	-0.005
	(2.857)	(0.012)	(0.013)
Outdoor	8.822***	0.010	0.014
	(3.376)	(0.014)	(0.014)
Magazine	0.430	0.022	0.021
	(2.076)	(0.032)	(0.032)

Notes: The same as those listed in table 1.

Table 5: Effects of the CAC's Promotions at the Market Level

	Radio			*Outdoor*		
	Retail Sales	Retail Price	Price Spread	Retail Sales	Retail Price	Price Spread
San Francisco	13.362**	-0.033	-0.028	1.320	0.029	0.038
	(5.522)	(0.023)	(0.024)	(5.841)	(0.026)	(0.026)
Los Angeles	7.920*	0.015	0.000	4.671	0.032*	0.025
	(4.870)	(0.017)	(0.023)	(5.333)	(0.019)	(0.022)
Denver	3.960	0.043	0.054	-4.254	0.072	0.081
	(4.658)	(0.047)	(0.051)	(5.108)	(0.052)	(0.056)
Phoenix	2.501	0.034*	0.032	4.739**	0.026	0.028
	(1.934)	(0.018)	(0.020)	(2.153)	(0.020)	(0.023)
Huston	5.481	-0.003	-0.003	7.722*	-0.031	-0.036
	(3.985)	(0.017)	(0.018)	(4.567)	(0.019)	(0.020)
Dallas	5.521**	0.017	0.026	3.168	-0.008	0.000
	(2.234)	(0.019)	(0.020)	(2.365)	(0.021)	(0.022)
San Antonio	29.811	-0.021	-0.021	144.079***	- 0.100***	-0.107***
	(36.112)	(0.031)	(0.030)	(39.823)	(0.033)	(0.032)
Seattle	1.610	0.004	0.002	2.752**	0.030	0.025
	(1.011)	(0.022)	(0.022)	(1.173)	(0.024)	(0.025)
Portland	-1.395	-0.001	0.005	2.836	0.065**	0.070**
	(1.456)	(0.026)	(0.028)	(1.761)	(0.030)	(0.032)
Atlanta	0.606	-0.053**	-0.415			
	(1.856)	(0.028)	(0.029)			
Hypothesis Test 1 H_0: Promotion coefficients are equal across the treated markets. (d.f. = 10 for radio promotions; d.f. = 9 for outdoor promotions)						
Chi-squared	17.08	15.28	12.29	26	15.71	26.66
p-value	(0.048)	(0.084)	(0.198)	(0.001)	(0.047)	(0.001)
Hypothesis Test 2 H_0: Promotion coefficients are equal to zeros in all the treated markets. (d.f. = 9 for radio promotions; d.f. = 8 for outdoor promotions)						
Chi-squared	17.38	19.95	13.04	26.03	22.40	26.69
p-value	(0.067)	(0.032)	(0.221)	(0.002)	(0.008)	(0.002)

Notes: The same as those listed in table 1.

Table 6: Base Values for Benefit-Cost Ratios (average values over 2002-2004)

Variable	Base Values
California production of avocados	363318812 pounds
Total CAC promotion expenditure	$4,568,245
Expenditure on radio promotions	$3,183,842
Expenditure on outdoor promotions	$1,133,780
Expenditure on magazine promotions	$256,623
Price elasticity	-1.33*

* Note: Carman and Craft (1998).