GIANNINI · FOUNDATION

OF AGRICULTURAL ECONOMICS

UNIVERSITY OF CALIFORNIA

An Economic Evaluation of the Hass Avocado Promotion Order's First Five Years

Hoy F. Carman, Lan Li, and Richard J. Sexton

Giannini Foundation Research Report 351

December 2009

UNIVERSITY OF CALIFORNIA
AGRICULTURE AND NATURAL RESOURCES

THE AUTHORS

Hoy F. Carman is professor emeritus and Richard J. Sexton is professor, Department of Agricultural and Resource Economics, University of California, Davis. Lan Li is research associate, National Institute for Commodity Promotion Research, Cornell University.

Contact: Richard Sexton, rich@primal.ucdavis.edu, 530.752.4428.

UC PEER REVIEWED This publication has been anonymously peer-reviewed for technical accuracy by University of California scientists and other qualified professionals.

TABLE OF CONTENTS

FIGURES

TABLES

1. INTRODUCTION

The U.S. avocado industry has evolved from an emphasis on seasonal domestic production of a mix of avocado varieties to year-round availability of domestic and imported Hass avocados. California avocado producers, who account for approximately 90% of U.S. avocado production and essentially all U.S. Hass avocado production, have funded promotional programs for avocados since 1961. With few imports of avocados prior to the early 1990s, the benefits from these demand-enhancing programs flowed directly to California producers. Imports of avocados into the United States have increased steadily since then, resulting in a free-rider problem that led ultimately to creation of the Hass Avocado Promotion, Research, and Information Act of 2000 that was signed into law by President Clinton on October 23, 2000. This act established the authorizing platform and timetable for creation of the Hass Avocado Promotion, Research, and Information Order (HAPRIO), which was approved in a referendum of producers and importers with 86.6% support on July 29, 2002.

This study evaluates the promotion activities conducted by the Hass Avocado Board (HAB) during its first five years of operation. The evaluation analyzes the impacts of the expenditures and the overall returns accruing to Hass avocado producers from all promotion programs. For some of the statistical methods employed in this evaluation, a five-year period provides insufficient data. In these situations, we evaluate the entire history of avocado promotion from the beginning of organized efforts in California in 1961 to the present.

Aside from providing new information on the effectiveness of promotion for an important California specialty crop, several features of the study distinguish it from predecessor works.[1] First, HAB is unique in that it involves two international importer associations, along with a domestic producer board, making evaluation of the effectiveness of this innovative alliance a unique undertaking.

Second, the study involves analysis of both aggregate annual time-series data, as has been common for perennial crops (Kaiser et al. 2005), and disaggregate scanner data collected at the retail level. These data enable the study to investigate the question of whether retailers, through their pricing strategies, capture a portion of the benefits of promotion through higher prices.

Finally, the study develops a benchmark methodology to evaluate the innovative information-sharing program implemented by HAB. By widely sharing information among market participants on harvests and shipments, HAB hopes to smooth flows of product to markets, prevent occurrences of shortages and surpluses, and stabilize prices at both free-on-board (FOB) and retail levels. We do find evidence of increased price stability in the presence of the program and translate that impact into reductions in the marketing margin based on the results for avocado price transmission provided in Li (2007).

Section 2 of the report discusses the major marketing programs conducted under the auspices of HAB. Section 3 provides an overview of trends in U.S. consumption of avocados, while section 4 contains a detailed analysis of annual demand for avocados in the United States with the goal of determining the impact that promotions have had on avocado demand. Section 5 introduces and implements a simulation framework to estimate the impact of avocado promotion on grower prices and incomes and on consumption of avocados based on the results of the demand analysis. Section 6 provides an analysis of avocado demand and the impact of promotion based on retail scanner data. Section 7 presents the analysis of the impacts of HAB's information-sharing and dissemination program. Finally, section 8 presents brief concluding remarks.

[1] Commodity promotion evaluation studies have been an important applied research topic in agricultural economics. The recent book by Kaiser et al. (2005) summarizes much of this literature.

2. AVOCADO PROMOTION PROGRAMS

The HAPRIO took effect on September 9, 2002, with program assessments beginning on January 2, 2003. The twelve-member board that administers the program under U.S. Department of Agriculture (USDA) supervision consists of seven domestic producers and five importers. Appointment of the first HAB members on February 12, 2003, initiated activities under the HAPRIO. The mandatory assessment rate is 2.5¢ per pound for all Hass avocados sold in the United States and the maximum permitted assessment is 5.0¢ per pound. HAB is required to rebate 85% of domestic assessments to the California Avocado Commission (CAC) and up to 85% of importer assessments to importer associations, which use the funds for their own promotion programs. HAB uses the remaining 15% of assessments for its operations, promotion, and information technology programs.

During its first five years of operation, HAB collected assessments totaling $98.67 million and rebated $77.6 million—$38.64 million to CAC, $20.54 million to the Chilean Avocado Importers' Association (CAIA), and $18.42 million to the Mexican Hass Avocado Importers' Association (MHAIA). Total five-year promotional expenditures were $50.98 million by CAC, $16.71 million by CAIA, $14.35 million by MHAIA, and $9.27 million by HAB, amounting to a total of $91.3 million spent on Hass avocado promotion in the U.S. market.

Even though the HAPRIO is only five years old, promotion of avocados in the U.S. market by California producers provides significant program experience on which to build. Using a state marketing order, the California avocado industry conducted generic advertising and promotion programs between 1962 and 1977 and has operated under provisions of CAC since September 1978. The California industry spent more than $334 million (in 2007 dollars) on advertising, promotion, and related services from initiation of the program in 1962 through 2002.[2] Total promotion expenditures by the California industry, including HAPRIO allocations for 2003–2007, were almost $398 million (in 2007 dollars). Additional promotional expenditures in the U.S. market by HAB, MHAIA, and CAIA from initiation of HAPRIO assessments in 2003 through the end of the 2007 marketing year totaled almost $42 million (in 2007 dollars).

Hass avocado promotion programs take many forms. CAC allocates the majority of its funds to consumer advertising and merchandising/trade promotions.[3] Significant expenditures are also made on food service, public relations, nutrition, and internet marketing programs. CAIA contracted with CAC to conduct its marketing/promotion programs for the first four years (from inception through the 2006 marketing year). In 2007 CAIA began conducting its own programs. MHAIA did not conduct any promotion programs in 2003 but has been active since 2004. HAB expenditures have emphasized national market communications and industry information programs.[4]

Annual promotion expenditures by the three associations are shown in Table 1. The California data are for marketing programs only (industry programs and administration are excluded) and HAB's data are for marketing communications only (information programs and administration are excluded). All organizational expenditures are reported for Chile and Mexico.

2.1. California Avocado Commission Programs

CAC typically allocates about 70% of its revenue from producer assessments to its marketing programs. Consumer advertising is the leading activity in terms

[2] The U.S. avocado marketing year runs from November 1 through October 31 of the following year. We use the convention of referring to the marketing year as the latter year; for example, we refer to November 1, 2002, through October 31, 2003, as 2003.

[3] CAC also collects additional funds from production of California Hass and other types of avocados to support its industry programs and other activities.

[4] Information in this section is based on each organization's annual business or marketing plans and budgets as available.

of expenditure with programs conducted in major markets across the United States. Consumer advertising messages and timing are tailored to individual markets. CAC's geographic emphasis continues to be on core markets in western states and developing markets in other regions.[5] Consumer advertising is focused on the period from February through August, which coincides with the California harvest. Radio has been the main medium for consumer advertising. Billboards, newspapers, and cable television are also used, depending on the market and message. National advertising programs have used cable television (Discovery Network, Food Network, and Fine Living), print (*Food and Wine* and *Saveur*), and the internet.

Merchandising and trade promotion programs take a variety of forms, including point-of-purchase materials, display contests, produce programs (AvoInfo/RipeMax), comarketing, trade advertising, retail tie-in events, and cooperative advertising. The main targets are supermarket chains and mass retailers. CAC's food service marketing efforts have focused on restaurant operators, institutions such as universities, and food service influencers, including editors, food writers, and trend-setting chefs.

CAC's health and nutrition research program is designed to work synergistically with its public relations efforts to establish and communicate the health and nutritional benefits of consuming avocados. Research was focused initially on a detailed analysis of the composition and nutrient content of avocados, including fatty acids, vitamins, and minerals. More recently, emphasis has shifted to quantifying and qualifying various phytochemicals (e.g., phytosterols, carotenoids, glutathione) as well as their health benefits and effects on disease processes. CAC made a strategic decision to focus on the use of public relations to disseminate the health and nutritional message for avocados rather than using paid advertising and promotion.

2.2. Chilean and Mexican Avocado Importer Association Programs

CAIA and MHAIA have a short history compared to CAC and information on their programs is limited. MHAIA conducted advertising and promotion programs for four of the five years in the evaluation period while CAIA's first independently operated program was conducted in 2007. Beginning with $700,000 of expenditures in 2004, MHAIA expanded its marketing budget and activities each year through 2007. MHAIA spent about two-thirds of its 2004 marketing funds on consumer advertising with 55% of total expenditures devoted to radio advertising. Trade advertising, including cooperative marketing funds and website expenditures, accounted for another 26% of total funds. The 2005 MHAIA budget increased to $2.9 million with $1.5 million (52%) spent on radio advertising. Importer cooperative marketing and public relations accounted for 31% of total funds with the remainder spent on websites, trade advertising, and administrative functions. With a total 2006 budget of $4.5 million, MHAIA spending on radio advertising increased to more than $2 million but radio

Table 1. **U.S. Avocado Promotion Expenditures in Dollars by Organization, 2003–2007**

Year	CAC	CAIA	MHAIA	HAB	Total
2003	8,682,060	1,427,000	0	146,499	10,255,559
2004	10,756,130	3,010,060	700,000	859,284	15,325,474
2005	11,838,029	5,742,600	2,900,000	2,603,124	23,083,753
2006	10,498,717	2,660,763	4,500,000	2,562,140	20,221,620
2007	9,205,138	3,864,637	6,246,500	3,096,859	22,413,134
Total	50,980,074	16,705,060	14,346,500	9,267,906	91,299,540

Note: The avocado marketing year runs from the preceding November 1 to October 31 of the year listed.

5 CAC's core markets in 2007 were Los Angeles, San Francisco, San Diego, Sacramento, Phoenix, Seattle, Portland, Dallas, San Antonio, and Houston. Its single select developing market was Atlanta.

advertising's total budget share decreased to 45%. Importer cooperative marketing, public relations, and trade advertising accounted for almost 32% of total expenditures in 2006. The major new expenditure of $498,000 was for a NASCAR sponsorship. With a total 2007 budget of $6,246,500, MHAIA spending on radio advertising increased slightly to $2,040,000 (32.7% of the total). With spending of $1.89 million, the share for importer cooperative marketing, public relations, websites, and in-store advertising was a little more than 27%. Spending on the NASCAR sponsorship and promotion increased to $1,423,500 (22.8%).

There is some annual information on CAIA marketing programs while it contracted with CAC but only aggregate expenditure data for its independent 2007 program. Note also that CAIA data that are available are for the period during each season when avocados from Chile are exported to the United States rather than for the California marketing year. Information for the period August 2003 through February 2004 indicates that the CAIA marketing program conducted by CAC included radio advertising, public relations, and merchandising. Radio advertising accounted for about 85% of expenditures on all programs. Four three-week radio campaigns were conducted in 2003/04 in twelve selected markets: August 18 through September 8 (including Labor Day), September 29 through October 20, November 10 through December 1 (including Thanksgiving), and December 29 through January 19, 2004 (leading up to the Super Bowl).[6] CAIA conducted the same marketing programs in the same markets the following season (April 2004 through February 2005). Total spending for radio programs during this period was $3.3 million. CAIA marketing programs from April 2005 through February 2006 were similar to the preceding two years with an emphasis on consumer radio advertising. Rather than the four three-week radio campaigns done previously, the 2005/06 campaign consisted of three three-week and two two-week programs. In 2007, CAIA also included television ads for general and Hispanic markets and sport and media promotion programs.

2.3. Hass Avocado Board Programs

HAB marketing programs fall under two major categories: information technology (InfoTech) and marketing communications (MarCom). InfoTech consists of *AvoHQ.com* on the internet and the Network Marketing Center, which are designed to exchange marketing and strategic information from all suppliers of Hass avocados to the U.S. market to improve the flow of fruit and maintain orderly marketing conditions. MarCom consists of consumer communications, online marketing, trade communications, industry communications, and marketing research. The MarCom share of HAB's budget has increased over time as the total HAB budget has increased and as the InfoTech program has become established. Initially in 2003, HAB spent $340,179 on InfoTech and $146,499 on MarCom. Expenditures grew for both programs in 2004 with $1,090,228 spent on InfoTech and $859,284 spent on MarCom. Consumer communications included Super Bowl and Cinco de Mayo promotions and public relations efforts that resulted in news releases with strong visibility. The website *avocadocentral.com* was established. MarCom became HAB's major expenditure category in 2005 with a budget of almost $2.7 million while InfoTech projects had a budget of $746,000.

MarCom's budget increased again to almost $3.5 million in 2006. Partnering with the Beef Checkoff and a Napa Valley winery, HAB collaborated to develop a 30-minute television program called "Hot Trends in Tailgating" that was aired on three cable networks (The Food Network, HGTV, and Fine Living Network). Six airings of the 30-minute show on each of the three networks were supplemented with 30-second consumer advertising spots that ran more than 100 times on four consecutive weeks on The Food Network, creating more than 27 million media impressions. The tailgating theme was continued in 2007 with a new partner (Miller Brewing) and a coordinated program with retailers, internet marketing, and public relations. MarCom expenditures increased to almost $3.2 million while InfoTech expenditures were $750,000.

[6] Thanksgiving, the Super Bowl, and Labor Day are holidays/events shown by Li (2007) to represent periods of high avocado consumption in the United States.

3. AVOCADO CONSUMPTION IN THE UNITED STATES

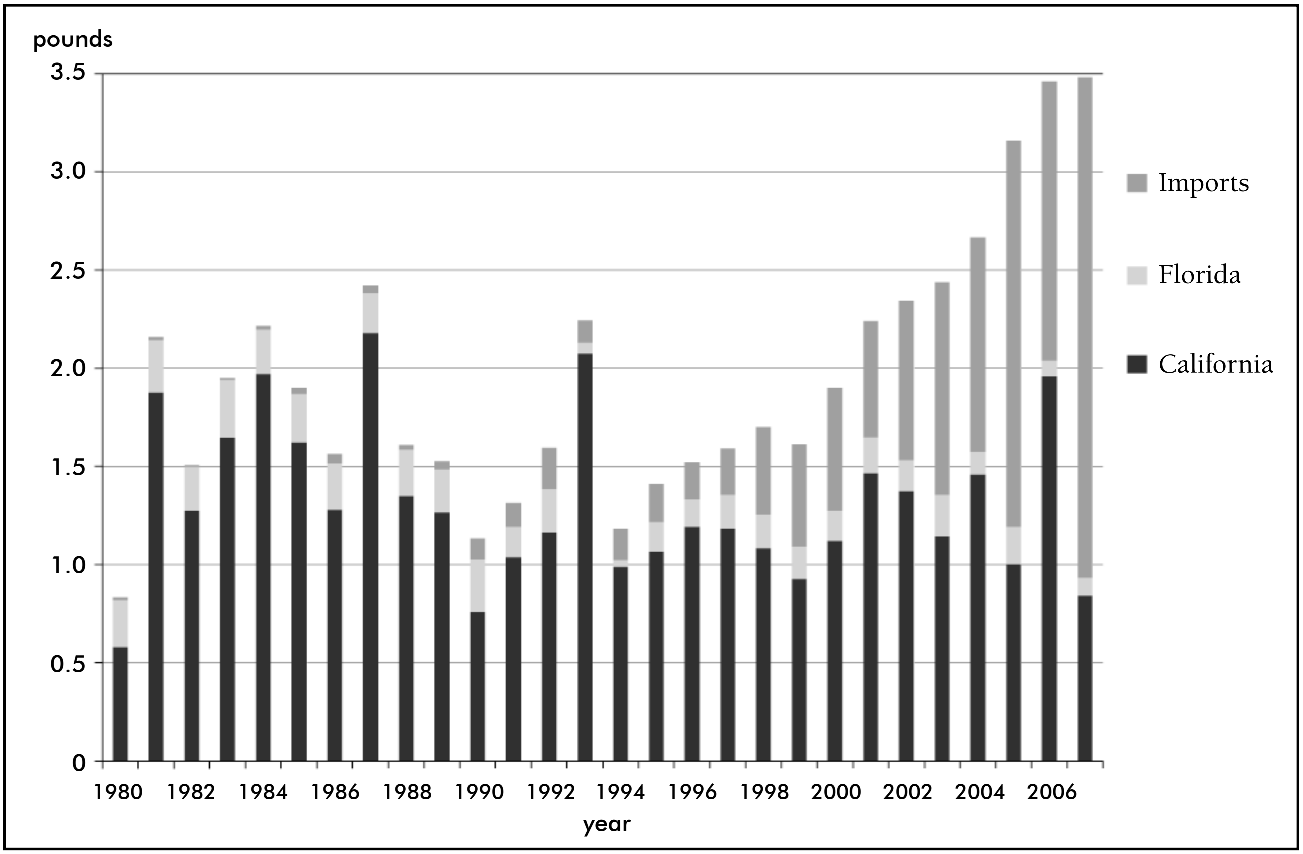
Avocados consumed in the United States before 1990 came largely from California production; export and import volumes were very small. Estimated U.S. avocado consumption remained below a pound per capita until 1975 when a large California crop pushed consumption to 1.2 pounds per capita. Avocado imports slowly increased during the last half of the 1980s and first exceeded 25 million pounds in 1990. Imports continued to expand through the 1990s and then exploded as Mexico gained access incrementally to the U.S. market. Imported avocados accounted for 26.1% of U.S. consumption in 1998 and reached 73.1% in 2007. Per capita consumption expanded with increased imports, reaching a record high of 3.45 pounds in 2006 and 2007. Estimated U.S. per capita avocado consumption for 1980–2007 by source of the avocados is shown in Figure 1, demonstrating the striking growth of imports in total and as a share of U.S. consumption.

Several factors are associated with increased U.S. avocado consumption. No doubt a key factor is the year round availability of good-quality avocados in the United States. Quality has been improved in part by industry-sponsored merchandising programs for produce personnel in supermarkets that stress the importance of proper ripening and having different maturity levels available for consumers. Industry promotion budgets have included nutrition programs for several years and have been successful in having avocados mentioned specifically as a recommended fruit in diet plans and food pyramids such as the Mediterranean Diet Pyramid and the Atkins Lifestyle Food Guide Pyramid.

Industry studies have also examined demographic characteristics of avocado consumers. Cook (2003) described the typical U.S. avocado purchaser as a woman 25–54 years of age, having an income of $50,000 plus, upscale, college educated, working full/part time, and health conscious. The most frequent uses for avocados are for guacamole, as part of a Mexican side dish, in a salad, eaten plain, in a sandwich or burger, and as part of a non-Mexican entrée (Cook 2003).

HAB (2007) sponsored research examining U.S. Hispanic consumers that tended to confirm some widely held industry perceptions, including that Hispanics buy significantly more avocados than the average consumer. For the time period tracked, 97% of Hispanic shoppers bought avocados as compared to 49% of the general population. In addition, 60% of Hispanic shoppers purchased avocados weekly and the average purchase of 4.8 avocados was 58% greater than the average for consumers overall. Research reveals two distinct segments of the Hispanic market: U.S.-born Hispanics who speak English in the home and foreign-born Hispanics in Spanish-language-dominant households. Hispanics born in the United States are more aware of the Hass variety but purchase fewer avocados than their foreign-born counterparts.

Figure 1. **Annual U.S. Per Capita Avocado Consumption by Source, 1980–2007**



4. MODELING ANNUAL DEMAND FOR AVOCADOS

This analysis benefits from a considerable base of prior research on the avocado market and avocado promotion. Previous studies provide analytical models and empirical estimates for avocado demand parameters, demand responses to promotion programs, and acreage responses to price changes. We discuss this work and provide an updated analysis in this section.

4.1. Previous Studies

Carman and Green (1993) estimated equations for price and acreage responses as major components of a simulation model of the California avocado industry that was used to estimate the impact of generic advertising on acreage and returns over time. The price equation, calculated at mean values, yielded a price flexibility of demand of −1.16 and a price flexibility of advertising of 0.15.[7] Carman and Cook (1996) used a revised and updated version of the Carman and Green model to examine possible impacts of avocado imports from Mexico on the California industry. The price equation, calculated at mean values, yielded a price flexibility of demand of −1.53 and an advertising flexibility of demand of 0.28.

Carman and Craft (1998) estimated both annual and monthly price equations for California avocados in a study of the returns to CAC promotion programs. The estimated annual flexibilities of demand for price and advertising were −1.33 and 0.13, respectively. Estimated monthly flexibilities of demand for price and advertising were −1.54 and 0.137, respectively.[8] They estimated that California avocado producers achieved an annual average benefit-cost ratio of 2.84 for the 34-year period covered by their analysis. Short-term returns, based on an assumption of fixed supply, ranged from $5.25 to $6.35 per dollar spent on advertising.

The USDA's Animal and Plant Health Inspection Service (APHIS) included an economic analysis of the potential economic impact of increased Hass avocado imports from Mexico in three reports issued on proposals to increase the number of states and time period for shipments of avocados from Mexico. In the 2001 and 2003 reports, APHIS used a price elasticity of demand of −0.86 (USDA 2001, 2003). For the 2004 study, the report used a price elasticity of demand of −0.57 (USDA 2004).[9] APHIS did not consider the possible impacts of advertising and promotion on demand for avocados.

The most recent analysis of the impact of promotion on U.S. avocado demand, based on annual data from 1962 through 2003, estimated that importers could realize returns ranging from $2.09 to $3.26 per dollar of HAPRIO expenditures with net returns decreasing as imports increase (Carman 2006, p. 476). This study assumed that the effectiveness of importer promotion expenditures would be equivalent to the effectiveness of CAC expenditures.

4.2. Econometric Models of the Annual Demand for Avocados

Estimated U.S. avocado demand equations in the cited studies included variables for per capita sales, real prices, income, promotion expenditures, and share of the population that is Hispanic. Other possible demand-shift variables (such as prices of possible substitutes and complements for avocados) and factors associated with trends in demand (including

7 The price flexibility of demand (advertising) is the percent change in price due to a 1% increase in sales (advertising). Thus, a 1% increase in advertising expenditures, for example, was estimated to increase the California FOB price by 0.15%.

8 The responsiveness of avocado demand to generic advertising found in these studies is consistent in magnitude to that found for several other California commodities. Alston et al. (2005, pp. 406–407), in their summary of commodity promotion programs, listed advertising flexibilities of demand of 0.13 and 0.16 for eggs and strawberries, respectively, and advertising elasticities of demand as follows: table grapes, 0.16; dried plums, 0.05; almonds, 0.13; walnuts, 0.005; raisins, 0.029 in Japan and 0.133 in the United Kingdom. Kinnucan and Zheng (2005, pp. 262–263, 270) summarize estimated elasticities and benefit-cost estimates for the dairy, beef, pork, and cotton promotion programs.

9 The price elasticity of demand is the inverse of the flexibility of demand estimated by Carman (2006) and others. Thus, all of these estimates are broadly consistent—demand for avocados is inelastic (or flexible), meaning that a 1% increase in price causes less than a 1% reduction in the quantity demanded.

increased seasonal availability of avocados due to imports, changing demographics, and the growing popularity of Mexican foods) have also been investigated but with limited success. Carman (2006, p. 472) introduced a variable for the percentage of Hispanics in the U.S. population as a measure of the impact of demographic changes and the increased demand for Mexican foods. He also examined use of variables to measure increased imports (and, hence, increased seasonal availability) and account for possible substitutes but none had a measurable impact on avocado demand.

Using the results of the previous studies and economic theory, we specified annual demand for avocados in the United States as a function of several explanatory variables:

(1) $Qa_t = f(Pa_t, A_t, Y_t, H_t)$

where the variables for a given crop year *t* are defined as follows.

- Qa_t is per capita U.S. sales (pounds per person) of avocados from all sources (California, Florida, and all imports) less exports from the United States.
- Pa_t is the average real FOB (farm) price of California avocados.
- A_t is the real total value of avocado advertising and promotion expenditures.
- Y_t is real per capita U.S. disposable income.
- H_t is the percentage of the total U.S. population that is Hispanic.

Prior to the creation of the HAPRIO, A_t consisted mainly of expenditures by CAC.

The consumer price index (CPI) for all items (1982–1984 = 1.00) was used to deflate prices, incomes, and promotion expenditures to a constant-dollar basis.[10] Detailed information on each of the variables used in the analysis, including means and standard deviations, is included in Table 2.

Table 2. **Variable Definitions and Summary Statistics**

Variable	Definition	Units	Range of Values	Mean Value	Standard Deviation
Qa_t	Annual average per capita U.S. sales of all avocados (California, Florida, and all imports)	Pounds per capita	0.39–3.48	1.49	0.797
Pa_t	Average annual FOB price of California avocados deflated by the CPI for all items (1982–1984 = 1.00)	Real cents per pound	14.33–113.88	50.85	21.656
Y_t	U.S. per capita disposable income deflated by the CPI for all items (1982–1984 = 1.00)	Thousands of real dollars	7.20–16.26	11.83	2.477
A_t	Annual advertising and promotion expenditures by CAC, HAB, CAIA, and MHAIA deflated by the CPI for all items (1982–1984 = 1.00)	Millions of real dollars	CAC: 0.60–7.55 HAB, CAIA, MHAIA: 0.86–6.37	CAC: 4.17 HAB, CAIA, MHAIA: 4.05	CAC: 1.744 HAB, CAIA, MHAIA: 2.333
H_t	Hispanic population as a percentage of total U.S. population	Percent	3.67–15.01	7.85	3.487

[10] Based on the results of previous studies, we do not include prices of substitutes or complements in the demand model for avocados. Variables that have been investigated previously as potential substitutes and found to be statistically insignificant include prices for fresh tomatoes, fresh peppers, and lettuce (Carman 2006). Products that could be complements, such as tortillas and salsas, do not offer readily available times-series data on price. In essence, the lack of statistical evidence that other food products are a factor influencing avocado demand means that avocados are a unique product in the diet of most consumers and they are not readily willing to substitute other fresh ingredients in place of avocados in their diets.

Hispanics' share of the U.S. population increased from 3.7% to 15.0% during the period of analysis, and U.S. Census Bureau projections show that the Hispanic share will increase steadily, reaching 24.4% in 2050. Mexico is the world's largest avocado producer and consumer with per capita avocado consumption recently reported at 8 kilograms or about 17.6 pounds annually compared to about 3.5 pounds per capita per year in the United States (USDA, Foreign Agricultural Service 2005). With approximately two-thirds of the U.S. Hispanic population originating from Mexico, this variable is intended to measure demographic change that may be related to avocado demand. The increasing Hispanic share of the U.S. population may also act as a proxy for the popularity of Mexican food and Mexican restaurants in the United States.

Consumer demand is inversely related to the price paid based on the "law of demand." A basic question is which price to use in the demand analysis. Retail prices differ across stores and grower prices differ by avocado type and country of origin. For example, California avocados generally receive a higher price than avocados from Chile or Mexico. We used the California grower or FOB price because it is the only price series that is available for the entire period of the data analysis. Prices for avocados from different origins (California, Florida, Chile, and Mexico) and at different stages of the market chain (farm, wholesale, and retail) should move in unison as a consequence of the "law of one price" so the choice of the specific price series should be of little consequence.[11] Another issue regarding price as an explanatory variable is its potential endogeneity. If prices and sales are determined simultaneously in the market place, then price is endogenous and correlated with the error term in an estimation of equation 1, rendering the estimates inconsistent. We address the potential endogeneity of the FOB price later in this section.

4.3. Preliminary Data Analysis

Before conducting the formal econometric analysis, it is important to undertake descriptive studies of the variables being considered. A basic problem in conducting an aggregate time-series analysis of economic relationships is that many variables tend to move together over time (to be cointegrated), making it difficult to isolate the unique impacts of each variable. From equation 1, we seek to explain changes over time in per capita consumption of avocados in the United States as a function of variables such as real per capita U.S. disposable income (Y_t), real expenditures to promote avocados (A_t), the Hispanic share of the U.S. population (H_t), and the real California grower price (Pa_t). Figures 2 and 3 illustrate a fundamental challenge. The Hispanic population share and per capita disposable income (Figure 2) have increased over the time period of the data set, 1962–2007, in a rather smooth, continuous fashion. Although promotion expenditures and per capita avocado consumption (Figure 3) have been somewhat more volatile, they too have trended upward over time. Among the explanatory variables contained in equation 1, the real California FOB price (Figure 3) is the only one that does not exhibit a significant upward trend.

Correlation coefficients reported in Table 3 measure comovement over time of the economic variables. Column 2 reveals that per capita consumption, the variable we seek to explain, is highly correlated with A_t, H_t, and Y_t as these correlation coefficients all range from 0.83 to 0.86. In fact, a simple trend variable, *YEAR*, constructed by setting its value to 1962 in the initial year of the data and increasing it by 1.0 for each successive year, has a similar correlation with per capita consumption. Of course, a high correlation does not imply that changes in one variable are "causing" the movements observed in the other variables. It merely denotes that they move together jointly over time.

[11] The law of one price follows from basic arbitrage. For example, prices for avocados from different countries of origin may differ for a variety of reasons, including perceptions of differences in quality. But as long as buyers are willing to substitute among the various offerings, the avocado prices should move in unison. The same argument pertains to prices at different stages of the market chain.

Figure 2. **Annual Per Capita Avocado Consumption, U.S. Per Capita Disposable Income, and the Percentage of the Population That Is Hispanic, 1962–2007**

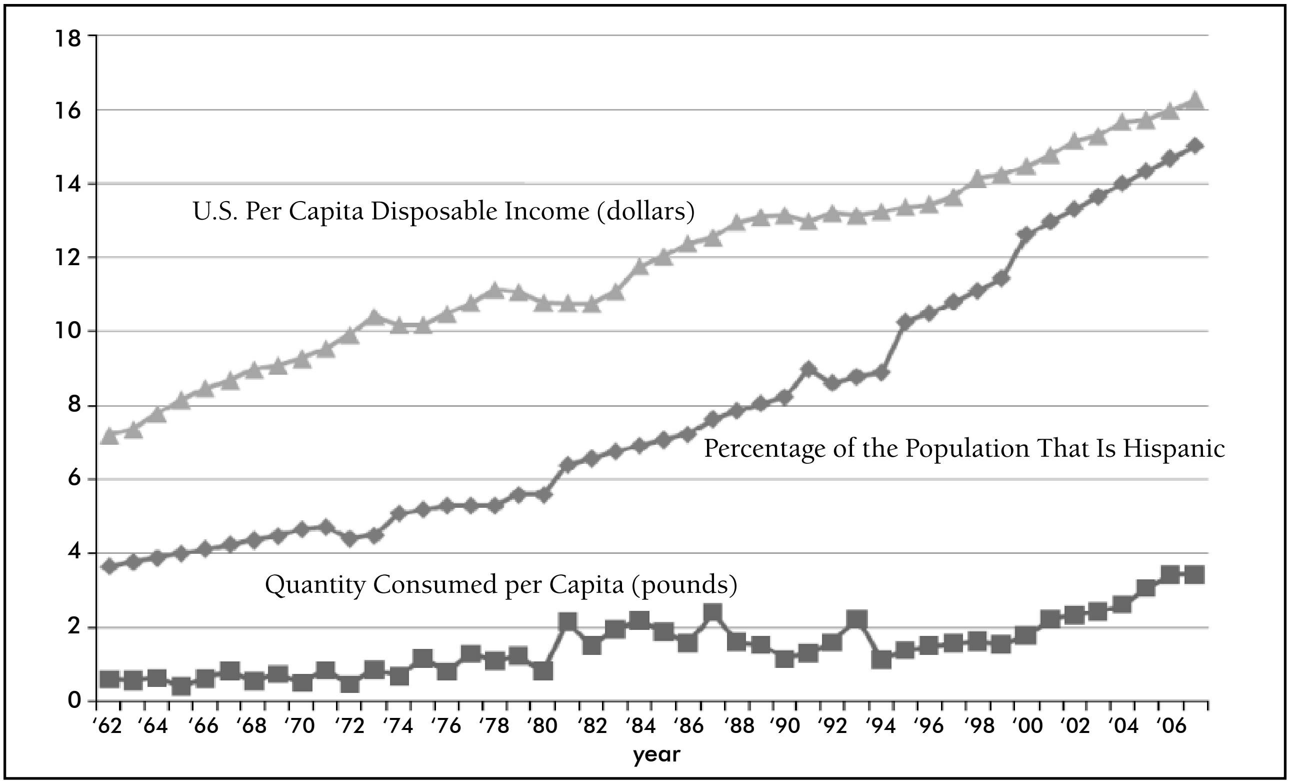


Figure 3. **Annual Per Capita Avocado Consumption, FOB Price, and Promotion Expenditure, 1962–2007**

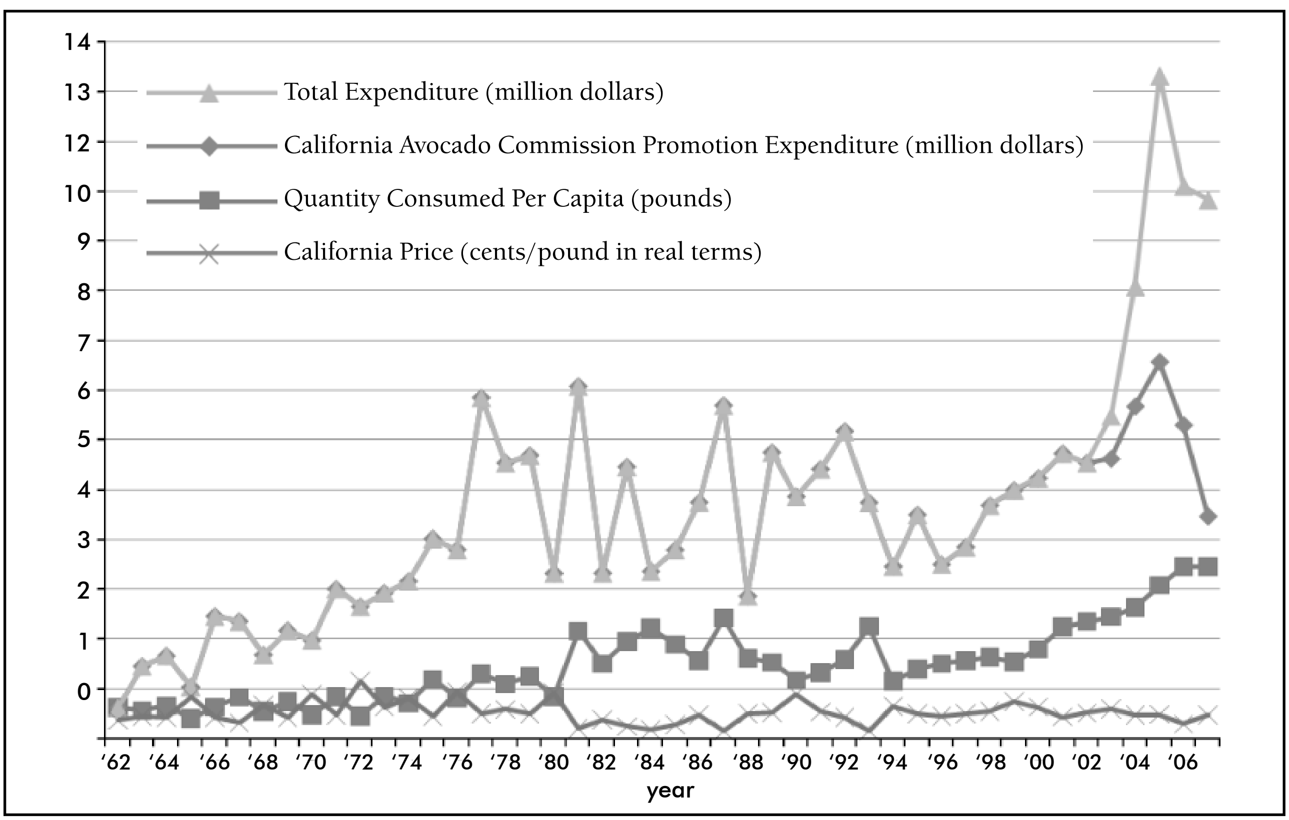


Table 3. **Correlation Coefficients for the Demand Model**

	Qa_t	Pa_t	*YEAR*	A_t	H_t	Y_t
Per capita consumption (Qa_t)	1.00					
Real California price (Pa_t)	−0.50	1.00				
YEAR	0.83	−0.15	1.00			
Real total promotion expenditures (A_t)	0.86	−0.25	0.74	1.00		
Hispanic share of population (H_t)	0.84	−0.15	0.97	0.75	1.00	
Real per capita disposable income (Y_t)	0.83	−0.12	0.99	0.77	0.95	1.00

Also important to observe is that Y_t and H_t are both highly correlated with *YEAR* as the correlation coefficients are 0.97 and 0.99 respectively. In essence, over the 1962–2007 period of our data, H_t and Y_t each have increased over time in a manner that can be almost perfectly predicted with a linear trend variable. Of course, H_t and Y_t are also highly correlated with each other. Real promotion expenditures (A_t), while quite highly correlated with H_t, Y_t, and *YEAR*, exhibit some independent comovement that is manifested by correlation coefficients with these three variables ranging from 0.74 to 0.77.[12] This is favorable information given the purposes of the study because the independence of movement of A_t creates the potential to isolate the impact of promotion on avocado consumption relative to impacts of the other variables. However, the extremely high correlation among H_t, Y_t, and *YEAR* means that there is no opportunity to isolate their individual impacts.

4.4. Structural Breaks in Per Capita Consumption

Among the challenges in estimating an annual demand model is that the fundamental economic relationships linking the variable of interest, per capita consumption in our case, to potential explanatory variables may change over time. In other words, there may be structural breaks in the data. This possibility is especially relevant for avocados given the significant changes that have occurred in the industry over the 1962–2007 period of analysis in terms of rapidly escalating imports and the availability of product year round. Examination of the plot of per capita consumption over time in Figure 3 reveals two potential disruptions in the upward trend in per capita consumption—an upward shift in consumption between 1980 and 1981 and a downward shift in consumption between 1993 and 1994. Furthermore, following the decline in per capita consumption between 1993 and 1994, the upward trend in consumption from 1994 onward has a higher trajectory than those of the preceding years, no doubt reflecting, at least in part, the progressive opening of U.S. markets to Mexican imports that began in 1997. A fundamental issue in the demand modeling is how to handle these structural shifts in consumption and the revised trend in consumption that began in 1994. If we do not account for these shifts through separate intercept-shift and trend variables and instead allow the changes in per capita consumption to be explained by the variables in equation 1, the estimated impact of the promotion variable is much greater, as is its statistical significance. These results are presented next.

[12] Formal tests for the time-series properties of the model variables were also conducted. These included tests of the null hypothesis that a variable is stationary (i.e., a variable that reverts to a constant mean and does not exhibit a deterministic trend) against the alternative hypothesis that the variable has a unit root (i.e., the variable has no mean and follows a "random walk"). Detailed results of these tests are available from the authors. Briefly, the California grower price, Pa_t, has no significant trend and is covariance-stationary (i.e., stationary without a deterministic trend). All of the other variables (per capita consumption, real promotion expenditure, real per capita disposable income, and percent of the population that is Hispanic) have a statistically significant trend that is apparent from examination of Figures 2 and 3. Per capita consumption and real promotion expenditure are trend-stationary (stationary after removal of a linear trend) while real per capita disposable income and percent of the population that is Hispanic each contain a unit root.

4.5. Estimated Annual Demand Relationships

Various demand functions based on equation 1 are estimated using 46 annual observations for the marketing years 1962 through 2007. The key objective is to determine the impact of total advertising and promotion programs on annual U.S. demand for avocados. Results from the alternative estimations are presented in Table 4. All of the estimations reported in Table 4 are conducted via ordinary least squares (OLS).

Several conclusions immediately follow from examination of Table 4. First, the overall explanatory power of the model is very high as measured by the adjusted R-square statistic, which measures the proportion of total variation in per capita consumption from 1962 through 2007 that is "explained" by the variables included in the model. Adjusted R-squares vary from about 0.92 to nearly 0.99 for the alternative models presented in the table.

Second, price is inversely related to per capita consumption in a way that is significant statistically and robust to alternative model specifications. This result is, of course, consistent with prior studies and simply affirms the law of demand but is gratifying nonetheless as an indication of an econometric model that is working properly. The estimated price elasticity of demand, evaluated at the data means, ranges from −0.41 to −0.46 depending on the model specification. Thus, demand is in the inelastic range, meaning that a 1% increase in production causes roughly a 2% decrease in the FOB price when other factors are held constant.[13]

Third, high correlation (multicollinearity) among the variables Y_t, H_t, and *YEAR* makes it impossible to estimate the individual effects of these variables on consumption. Recall that each of these variables is almost perfectly correlated with the other two. Thus, although we know from economic theory, past research, and basic information on the avocado industry that per capita consumption is likely to be positively related to per capita income and to the Hispanic share of the U.S. population, it is not possible to isolate these two effects or, for that matter, to separate their effects from a simple trend variable that could be capturing the effects of both Y_t and H_t and other omitted variables affecting consumption.

This multicollinearity among Y_t, H_t, and *YEAR* manifests itself in terms of estimated effects for each of these variables being unstable and highly sensitive to model specification. For example, model 3 shows an inverse (and statistically insignificant) effect between H_t and Qa_t and also between *YEAR* and Qa_t. But these results are due merely to the statistical program imputing all of the impact of these three upward-trending variables to Y_t in this model. In essence, due to their high multicollinearity, this attribution of impact is almost arbitrary. This can be seen in terms of the sensitivity of the results for these variables to minor changes in the model specification. Importantly, because our main interest is in evaluating the effect of promotion, this inability to separate impacts due to Y_t, H_t, and *YEAR* does not constitute a significant limitation on the analysis.

Fourth, promotion has had a positive effect on demand that is statistically significant for all models presented in Table 4. However, the magnitude of the promotion impact hinges on whether we account separately for the shift in per capita consumption that occurred between 1993 and 1994 and the increasing trend line for per capita consumption that began in 1994 and continues through the data set. The downward shift in per capita consumption is captured by the dummy variable *D1994–2007*, which is negative and statistically significant in models 3 and 4. The greater trend upward in consumption that begins in 1994 is captured by the trend variable *YEAR1994–2007*, which is 1994 in the year 1994, increases by 1.0 for each subsequent year, and is zero for all years preceding 1994. Importantly, this change in trend cannot be explained by the other three variables in the model (Y_t, H_t, and *YEAR*) that are each trending upward smoothly through time. All three of those variables are included in model 3 and Y_t and H_t are included in model 4. *YEAR1994–2007* is positive and statistically significant despite the presence of these other variables.

[13] Though the estimate of price-inelastic demand in this study is lower (more inelastic) than those from prior studies, the estimate remains consistent with the other studies of avocado demand due to higher rates of avocado consumption in the United States that began in the 1990s and have continued to the present, moving consumption down the demand curve into more inelastic regions.

Table 4. **Estimated Annual Demand Models: Ordinary Least Squares**

	Model 1		Model 2		Model 3		Model 4	
	Base Model		Base Model + Trend		Model 2 + Structural Break for 1994–2007		Model 3 without *YEAR*	
Variable	Estimate	|t-stat|	Estimate	|t-stat|	Estimate	|t-stat|	Estimate	|t-stat|
California FOB price (Pa_t)	−0.0120 [−0.414]	(7.48)	−0.0125 [−0.431]	(7.32)	−0.0132 [−0.455]	(8.69)	−0.0131 [−0.451]	(8.66)
Per capita income (Y_t)	0.0739 [0.592]	(1.56)	0.1782 [1.429]	(1.43)	0.1904 [1.526]	(2.88)	0.1389 [1.114]	(3.97)
Hispanic share of population (H_t)	0.0609	(1.87)	0.0798	(2.06)	−0.0103	(0.15)	0.2878	(0.56)
Total promotion (A_t)	0.1192 [0.372]	(5.79)	0.1110 [0.347]	(4.93)	0.0475 [0.148]	(2.04)	0.0562 [0.176]	(2.66)
YEAR			−0.0230	(0.91)	−0.0001	(0.92)		
YEAR1994–2007					0.0902	(3.59)	0.0795	(3.58)
D1994–2007					−180.2921	(3.60)	−158.9093	(3.59)
Constant	0.1850	(0.58)	44.485	(0.91)				
Adjusted R^2	0.9192		0.9188		0.9879		0.9879	

Note: Absolute t-statistics are indicated in parentheses; elasticities evaluated at data means are in brackets.

The one variable in the model that can account, at least partially, for this increase in the consumption trend line is total promotion, which also exhibits an increasing rate of trend beginning about this same time and escalates especially rapidly with the creation of the HAPRIO. Thus, introducing separate shift (*D1994–2007*) and trend (*YEAR1994–2007*) variables to account for this evident change in per capita consumption eliminates roughly half of the estimated impact of the promotion variable. This is demonstrated by a comparison of the results from models 1 and 2 with the results of models 3 and 4. Promotion effects are nonetheless positive and statistically significant even in models 3 and 4. The estimated elasticity of demand with respect to promotion ranges from 0.148 to 0.372 depending on the model specification. The upper end of this range is high relative to prior estimates for the avocado industry and relative to other promotion studies generally. The lower end of the range is very consistent with prior estimates for avocados and in general.

We do not consider it possible to obtain a reliable separate estimate of the impact of promotion expenditures funded by HAB (i.e., expenditures in the last five years) using an annual model. The main problem is that the creation of HAB was stimulated in large part by the rapid increase in avocado imports into the United States and the growing free-rider problem caused by importers not contributing to advertising programs funded through CAC. Thus, HAB's naissance and commencement of funding programs under its auspices are associated with rapidly rising per capita consumption of avocados in the United States. Any variables created to measure HAB's influence on consumption (apart from the general influence over time of promotion as measured by A_t) will necessarily capture the rising trend in consumption much in the same way that it is captured presently by the variable *YEAR1994–2007* in models 3 and 4. The creation of HAB occurred essentially simultaneously with the rapid increase in imports and associated increase in domestic consumption. As a result, we cannot impute a causal relationship from HAB's creation and commencement of its funding programs to the increase in per capita consumption. Again, the industry's ability to withstand the rapid escalation of imports without enduring drastic decreases in real prices demonstrates that demand grew substantially over this period and the analysis suggests that this demand growth is at least partially due to promotion.

4.6. Diagnostic Checks of Annual Demand Models

Here we report briefly on diagnostic tests of the models reported in Table 4. These tests are important in determining the confidence that we can have in the estimated results.[14] The ability to attach confidence intervals to estimated effects and conduct statistical tests (such as whether the effect of promotion is statistically different from zero) depends on the properties of the estimated residuals (actual per capita consumption in year t minus predicted per capita consumption in year t). The tests confirm that the estimated residuals are homoskedastic (i.e., they have a constant variance) and distributed normally. Both are desirable properties that support the use of the model for hypothesis tests.

The residuals do, however, reveal some evidence of serial correlation, i.e., the expected value of the error in period t is a function of the error in period $t-1$. The estimated coefficients are consistent in the presence of serial correlation but the estimated standard errors (used to construct the t-statistics) need to be adjusted to correct for the presence of serial correlation. A more insidious problem is that serial correlation of the errors may create problems of endogeneity of the explanatory variables.[15] Elimination of serial correlation in the errors may thus eliminate some endogeneity problems.

Among the explanatory variables in the model, two are candidates for being endogenous: Pa_t and A_t. The California FOB price may be endogenous because it could be determined contemporaneously with consumption through the ordinary workings of the market. Promotion expenditures could be endogenous because the total budget for promotion is determined by the check-off rate multiplied by the total production of avocados that are subject to the check-off. Realistically, there is a lag between realization of production and consumption, collection of the check-off funds, preparation of marketing budgets, and actual expenditures on promotion so it is reasonable to believe that promotion expenditures during year t were determined for the most part by production in year $t-1$. Therefore, A_t is exogenous unless errors are serially correlated.

Our strategy is to address the endogeneity of the California FOB price using the two-stage least squares (2SLS) estimation procedure because good instruments for it are available as described in the next subsection. Unless there is strong evidence of autocorrelated residuals in the 2SLS estimation, we can be relatively confident that A_t is exogenous for the reasons noted.

4.7. Two-Stage Least Squares Estimation

Based on the OLS results, two models were considered in the 2SLS estimation. Model 1 includes only *YEAR* to capture the linear trend effect present in all three variables. Model 2 adds Y_t as an explanatory variable. The first-stage estimation involves regressing Pa_t on a set of exogenous instruments. The second stage involves using the predicted value, $\hat{P}a_t$, in place of actual Pa_t and re-estimating the annual demand

[14] Details on various diagnostic tests are available from the authors.

[15] Endogeneity is more likely in the presence of serially correlated errors because an explanatory variable with a value in period t that is determined, say, by events in period $t-1$ (and would thus be uncorrelated with the error term in period t in the absence of serial correlation) becomes correlated with the error term in period t and, hence, endogenous if the error term is serially correlated.

model. Using $\hat{P}a_t$ in place of Pa_t should eliminate the variable's correlation with the error term.

The key criteria for selection of instruments are that they must be exogenous and correlated with Pa_t. The instruments selected for the stage-one regression are the total U.S. avocado acreage harvested, the total Chilean avocado acreage harvested, the total Mexican avocado acreage harvested, and the import price for avocados in the world market.[16] Stage-one regression results are shown in Table 5 for models 1 and 2. Diagnostic tests support the validity of the instrumental variables in each case. The Shea Partial R-squared statistic for model 1 (model 2) is 0.358 (0.245), which, in the case of a single endogenous variable, coincides with the F-test for joint significance of the excluded instruments. This test yields F = 5.16 (2.92) with a p-value of 0.0021 (0.345). Lagrange multiplier tests similarly reject the null hypothesis that the first-stage equation is underidentified.

The second-stage estimation results are reported in Table 6. Given the high level of multicollinearity among Y_t, H_t, and *YEAR*, inclusion of Y_t does not improve the estimation and its estimated coefficient is negative (counter to the expected positive relationship between avocado consumption and income) and is not statistically significant.

The model shows a small increasing trend in consumption of about 0.036 pounds per year (model 1) until 1994, when the trend line spikes upward, increasing at about 0.132 (0.036 + 0.096) pounds per capita annually. The promotion effect is positive and statistically significant in both models but the estimated impact of promotion is reduced due to inclusion of the interaction term for *YEAR* (trend) and the *D1994–2007* dummy variable.

The 2SLS models have good statistical properties. We cannot reject promotion expenditure as exogenous based on the Sargan statistic. Homoskedasticity of

Table 5. **The First-Stage Regression to Predict California FOB Price**

	Model 1		Model 2	
Variable	**Estimate**	**|t-stat|**	**Estimate**	**|t-stat|**
Total promotion (A_t)	−5.1808	(2.31)	−5.1809	(2.32)
Per capita income (Y_t)			15.1428	(1.22)
YEAR	0.6724	(0.36)	−3.0573	(0.86)
YEAR1994–2007	−0.4720	(0.12)	−1.7752	(0.45)
D1994–2007	932.2922	(0.12)	3,540.542	(0.45)
World import price	0.6129	(3.24)	0.5495	(2.82)
U.S. avocado acreage	−0.4831	(1.35)	−0.3367	(0.90)
Chilean avocado acreage	0.7462	(0.56)	1.1190	(0.83)
Mexican avocado acreage	0.0524	(0.21)	0.0928	(0.37)
Constant	−1,288.783	(0.35)	5,913.128	(0.85)
Centered R^2	0.4167		0.4400	
Shea partial R^2	0.3580		0.2448	
Number of observations	46		46	
F-test of excluded instrument variables	F(4, 37) = 5.16 P-value = 0.0021		F(4, 36) = 2.92 P-value = 0.0345	

[16] Harvested acreage is expected to be a good instrument for price because it is determined in advance of price and, through the link between acreage and total production, should be correlated with price.

Table 6. **Estimated Annual Demand Models: Two-Stage Least Squares**

	Model 1		Model 2	
Variable	**Estimate**	**|t-stat|**	**Estimate**	**|t-stat|**
Predicted California FOB price	−0.0117	(5.64)	−0.0109	(3.86)
Per capita income (Y_t)			−0.0698	(0.53)
Total promotion (A_t)	0.0492	(2.34)	0.0527	(2.32)
YEAR	0.0362	(8.20)	0.0494	(1.92)
YEAR1994–2007	0.0964	(5.99)	0.0988	(5.86)
D1994–2007	−192.778	(5.99)	−197.587	(5.86)
Constant	−69.899	(8.05)	−95.385	(1.93)
Centered R^2	0.96		0.96	
Number of observations	46		46	

residuals is not rejected based on the Pagan-Hall test and the hypothesis that the residuals are not autocorrelated of order 1 cannot be rejected under any versions of the Cumby-Huizinga tests.

Finally, based on the Ramsey/Peseran-Taylor Reset test, we cannot reject the null hypothesis that the true relationship among the variables is linear.[17]

4.8. Summary

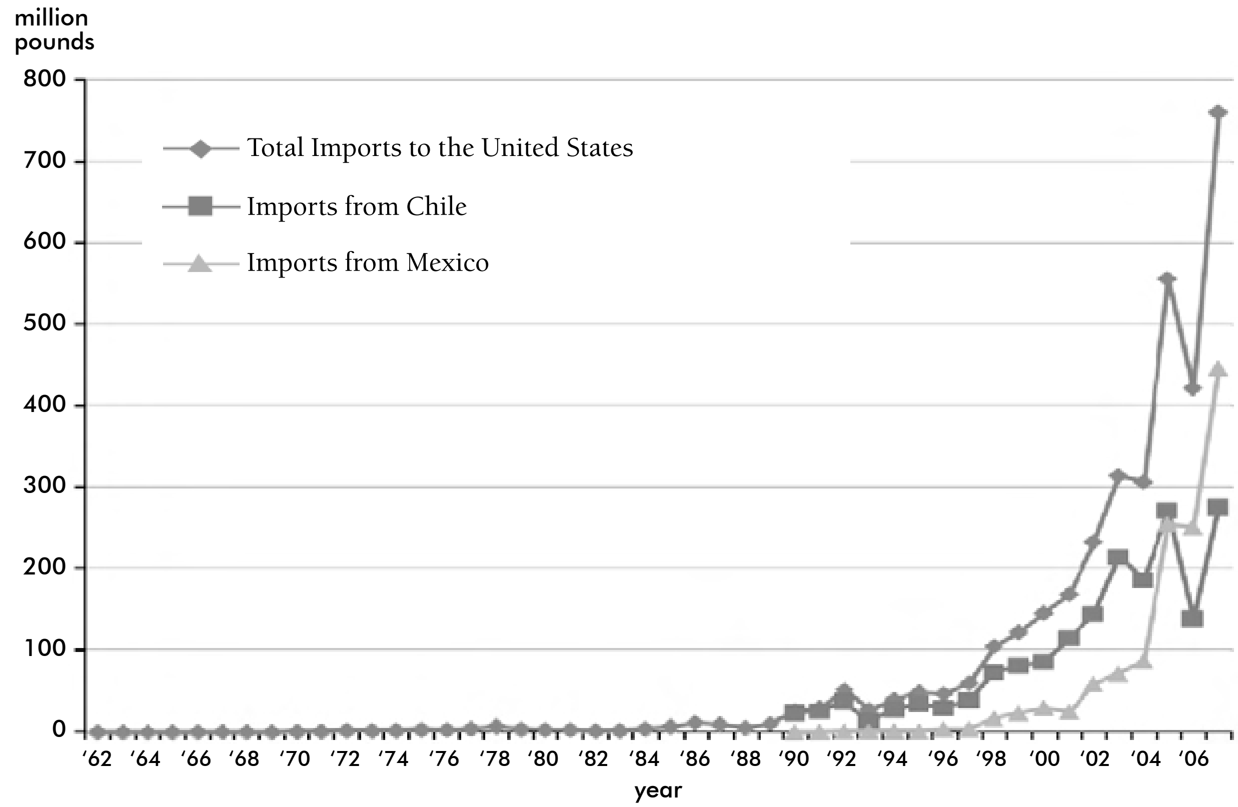
As illustrated in Figures 1 and 4, imports of avocados into the United States increased dramatically beginning in the early 1990s and have continued to increase since. The evidence from this study and prior studies suggests that avocado demand in the United States is price inelastic. Thus, a given percentage increase in supply will cause a greater and opposite percentage change in price. Rapid supply growth in the presence of inelastic demand can be a disastrous combination for an industry in the absence of demand growth. Yet, as the record shows (Figure 3), the real farm price in California has not fallen appreciably during this period of rapidly escalating imports, meaning that demand has expanded sufficiently to keep real prices relatively stable.[18]

In general, demand for food in the United States grows very slowly. In a high-income nation, most people have sufficient food to eat. Therefore, as their incomes and expenditures grow, little of the incremental expenditure goes for food. Unquestionably, avocado demand in the United States has expanded during this period at a much faster rate than demand for food generally. The only variable in our model that is capable of explaining the increasing trend line is promotion. For example, per capita income and the Hispanic share of the population do not exhibit a similar increase in trend lines.

[17] Evaluations of commodity promotion programs often specify a nonlinear effect between promotion expenditure and demand. The economic basis for this specification is that promotion must eventually have a diminishing return. Otherwise, in theory, it would be possible to expand demand indefinitely by spending ever increasing amounts of money to promote the product. However, such diminishing returns may not be observed if the actual amount of expenditure is less than the amount that coincides with the onset of diminishing returns. We estimated various models with a nonlinear relationship between promotion expenditure and per capita consumption but none improved the model's performance. This outcome is consistent with the results from the Ramsey/Peseran-Taylor Reset test.

[18] To be more precise, a regression of real California FOB price for 1994 through 2007 on a constant and a linear trend results in the following equation: $\hat{Pa}_t = 58.86 - 1.095 YEAR$. The absolute t-statistic on the *YEAR* coefficient is 1.63. Thus, the real price is estimated to have fallen by about 1¢ per year but the effect is not statistically significant at 90% or higher confidence levels.

Figure 4. **Avocado Supply, Imports, and Domestic Production in the United States, 1962–2007**



Notes: Total U.S. avocado consumption equals the sum of avocado production in California and Florida and total avocado imports minus total avocado exports. Total U.S. avocado production equals the sum of avocado production in California and Florida.

5. BENEFIT-COST ANALYSIS

The econometric analysis reported in section 4 presents strong evidence that generic promotion of avocados has worked to increase the demand for avocados in the United States. The additional question to ask, however, is whether the promotion expenditures have paid off in the sense of yielding benefits to producers from demand enhancement that exceed the money expended to fund the programs. We address that question in this section.

5.1. Benefit-Cost Analysis in Promotion-Evaluation Studies

Two types of benefit-cost ratios are relevant in promotion-evaluation analyses—average benefit-cost ratios (ABCRs) and marginal benefit-cost ratios (MBCRs). For producers, the ABCR from a promotion program consists of the total incremental profit to producers generated by the program over a specified time interval divided by the total incremental cost borne by producers to fund the program. Both the profit and cost streams should be properly discounted or compounded to a common point in time. The ABCR is the key measure of whether a program succeeded with an ABCR that is greater than or equal to 1.0 defining success.[19] The MBCR measures the incremental profit to producers generated from a small expansion or contraction of a promotion program. That is, the MBCR determines whether expansion of the promotion program would increase producer profits. An MBCR that is greater than 1.0 indicates a program that could have been profitably expanded.

In general, the ABCR does not equal the MBCR because promotion is usually modeled as having a nonlinear effect on demand. For example, the square-root function is often used to represent the relationship between promotion and demand and this functional form guarantees a declining effect of marginal promotion dollars on sales (e.g., Alston et al. 1997). Thus, the ABCR is greater than the MBCR for the square-root model. As discussed in section 4, we utilize a linear model to depict the functional relationship between demand and promotion expenditures and this relationship is not rejected by econometric tests. For the linear model, the ABCR equals the MBCR and, thus, the two questions—was the program profitable and could it have been profitably expanded—are one and the same.

Our strategy is to simulate the impact of a small hypothetical increase in HAB's assessment rate from the current level of \$0.025 to \$0.030 per pound (an increase of one-half cent per pound) and estimate the benefits and costs to avocado growers from that assessment expansion. The ratio of estimated benefits to costs is then the estimated MBCR. Given that the functional relationship is linear, it is also an estimate of the entire program's ABCR.

The simulation framework is depicted in Figure 5. The model begins with demand and supply functions for avocados that depict the current market. Thus, demand, D, is total U.S. demand as estimated in section 4 on a per capita basis. Supply, S, is total supply to the U.S. market from all sources. The precise "shape" of this supply relationship is a matter of some importance for the simulation model and will be discussed shortly. Under the current program, total U.S. consumption given functions S and D is Q_A and price is P_A. Implementation of a one-half cent expansion in the program assessment has the effect of increasing producer costs by one-half of a cent, which shifts supply upward to curve S' as depicted in Figure 5.

The additional funds generated by the program expand the level of demand by an amount equal to the incremental funds generated by the assessment multiplied by the estimated marginal impact of the promotion expenditure on demand. The incremental funds are simply the change in assessment multiplied by total shipments to the U.S. market and the estimated marginal impact is the regression coefficient for the promotion variable, A_t, which is reported for alternative model specifications in Tables 4 and 6. The new demand curve is illustrated in Figure 5 by D'. The

[19] Because the streams of both benefits and costs are discounted or compounded at an interest rate intended to represent the industry's opportunity cost in terms of alternative investments, the benefit-cost ratio is automatically adjusted for the opportunity cost of the funds used to support promotion.

new market equilibrium is found at the intersection of curves S' and D' at point A in Figure 5. The equilibrium price has risen to P' and sales have risen to Q'.

Producer benefits from the hypothetical expansion of the promotion program are measured in terms of producer surplus, *PS*, which is the same as producers' variable profits (i.e., the producer surplus equals the producer price multiplied by output minus the variable production costs associated with producing and selling the output). In Figure 5, *PS* in the absence of the promotion program is measured by the revenue rectangle $P_A x Q_A$ minus the area below the supply curve (the triangle $0CQ_A$), which represents the total variable costs associated with producing and selling output Q_A.

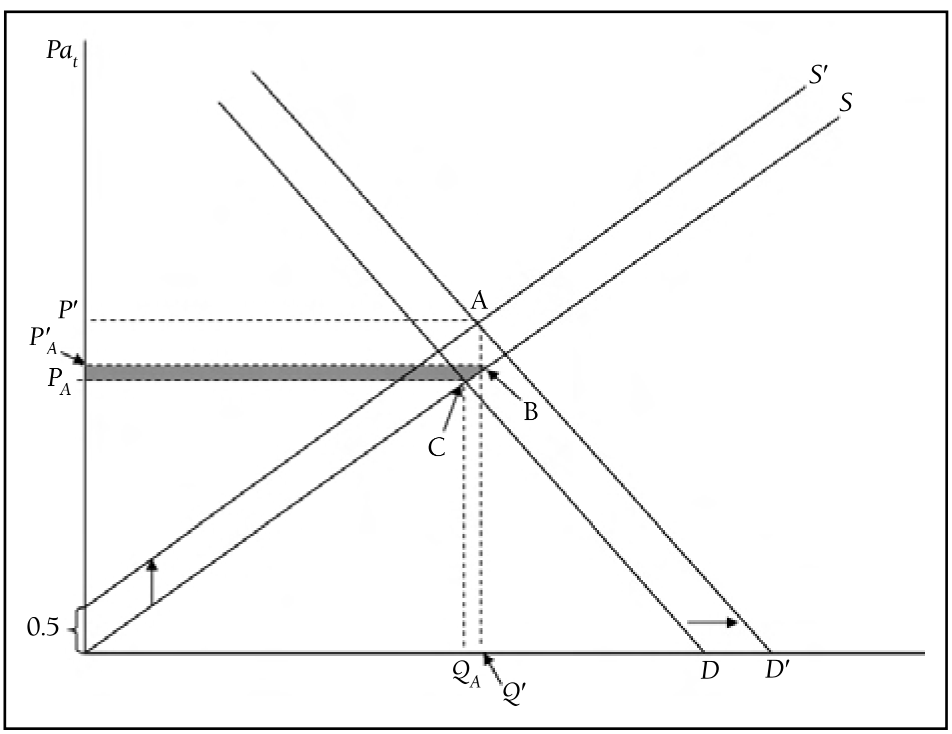
We seek to measure the change in producer surplus associated with the hypothetical expansion of the promotion program. In Figure 5, *PS* after the program expansion is $PS' = P'Q' - 0BQ'$ but we must also account for the additional promotion expenditure, which is the rectangle $P_A'P'AB = (P' - P_A')Q'$. Thus, the net increase in surplus to producers from expansion of the promotion program is $\Delta PS = PS' - (P' - P_A')Q'$, which is represented by the shaded area in Figure 5.

Three pieces of information are necessary to estimate ΔPS: (1) estimates of the marginal impact of promotion expenditures on demand, (2) estimates of the slope or price elasticity, ε_D, of demand, and (3) estimates of the slope or price elasticity, ε_S, of supply of avocados to the U.S. market. We have estimates of the first two from the econometric models summarized in Tables 4 and 6 but lack an estimate of ε_S. Most promotion evaluation studies do not attempt to estimate the elasticity of the supply relationship. Supply functions are difficult to estimate empirically and the elasticity varies by the length of run (time frame) under consideration. For example, supply becomes more elastic (responsive to price) in the long run as more productive inputs become variable to producers. Supply analysis is particularly difficult for perennial crops because the analyst must normally specify a dynamic model containing equations for plantings, removals, bearing acreage as a function of plantings and removals, and yield.

Carman and Craft (1998) analyzed supply response in the California avocado industry. Avocado supply to the United States is now complicated relative to the time period analyzed by Carman and Craft by the fact that both Chile and Mexico are important suppliers to the U.S. market as well as to their own domestic markets and other export markets. Thus, the Chilean and Mexican supply to the U.S. market is a residual supply that is based on total production and domestic demand in each country and demand from all importing countries except the United States.

The alternative and increasingly popular approach to studying the supply relationship is to estimate benefit-cost ratios for a range of plausible values for ε_S. If the conclusions are robust across the range of supply elasticity values chosen, there is little need to worry about choosing among the plausible alternative values. Examples of the alternative

Figure 5. **Avocado Promotion Simulation Model**



approach include Alston et al. (1997) for California table grapes, Alston et al. (1998) for California prunes, and Crespi and Sexton (2005) for California almonds. In considering a range of plausible values for ε_S, note that short-run supply of a perennial crop is highly inelastic because it is the product of bearing acreage and yield, neither of which is likely to be influenced much by current price. Thus, the supply of avocados from California is likely to be highly inelastic. The supply to the United States emanating from Chile and Mexico, however, is apt to be more elastic because the total supply in each country can be allocated to domestic consumption or to various export markets. Thus, an increase in price in the United States due to successful promotion, for example, is likely to cause Chilean and Mexican shippers to increase supply to the United States. Based on these considerations, we specified three alternative values for ε_S: 0.5, 1.0, and 2.0.

Among the available demand models shown in Tables 4 and 6, we selected two: model 2 from Table 4 (OLS) and model 1 from Table 6 (2SLS). Both models have good statistical properties and, because model 2 from Table 4 has a high promotion impact relative to model 1 in Table 6, the choices effectively provide an upper and lower bound to the MBCR given the econometric analysis.

Benefits and costs are estimated for each year of HAB's existence, 2003–2007. The model was implemented by "forcing" the demand and supply functions to intersect at the actual values for real price and quantity for each year, generating curves *D* and *S*, which intersect at quantity Q_A and price P_A in Figure 5.[20] Curve *S* was then shifted vertically to *S′* by the half-cent excise tax. Curve *D* was shifted horizontally to *D′* by the estimated promotion coefficient multiplied by the funds generated by the incremental assessment, producing the equilibrium at point A in Figure 5 and enabling us to compute the hypothetical changes in *P* and *Q* and the change in producer surplus in the manner described in prior paragraphs.

The results of the benefit-cost simulation are reported in Table 7. Six sets of estimates are reported—one for each combination of the three supply elasticities and two demand models chosen. For each simulation model, Table 7 reports the estimated change in real FOB price in cents per pound and the change in per capita consumption in pounds for each year of the program's existence. Total net producer benefits are reported for each model by compounding the annual benefits and costs from the hypothetical program at a 3% real rate of interest. The benefit-cost ratio reported in each table is computed by adding the program cost to the net benefit to produce the gross benefit and dividing the gross benefit by the total cost:

$$\text{MBCR} = \text{ABCR} = \frac{\Delta PS + \text{Assessment Cost}}{\text{Assessment Cost}}$$

The greater the elasticity of the supply function, the lower the estimated dollar benefit and benefit-cost ratio are. This result reflects the important principle that an expansion of supply in response to a promotion-induced increase in demand limits the benefit of the demand expansion. The greater supply attenuates the price increase that would otherwise occur. The estimated dollar benefit and the benefit-cost ratio are also lower for the 2SLS model because that model's estimated promotion coefficient is only 44% as great as the one in model 2 under the OLS. The estimated benefit-cost ratios range from 1.12 to 6.73. That each exceeds 1.0 is important as it is thus highly likely that (1) the promotion program supported by HAB during its first five years yielded net benefits to producers and (2) the programs could have been profitably expanded during the period of analysis (2003–2007).[21] To place these benefit-cost ratios in perspective, the most conservative ratio of 1.12 indicates that the 2.5¢ per pound assessment paid by each avocado producer returned 2.8¢ per pound for a net return of 0.3¢ per pound. At the other end of the spectrum (greater demand response to promotion and inelastic supply), the benefit-cost ratio of 6.73 indicates that the 2.5¢ per pound assessment returned 16.8¢ per pound for a net return of 14.3¢ per pound.

[20] In other words, the demand curve with the estimated slope coefficient from the chosen econometric model was shifted by its estimated error in year *t* so that the estimated function precisely fit the observed real price and quantity in year *t*.

[21] Note that Carman and Craft's (1998) estimate of the ABCR for CAC's promotion programs was 2.84.

Table 7. **Simulation Model Results**

Table 4, Model 2 (OLS)		Table 6, Model 1 (2SLS)	
Supply Elasticity = 0.5			
ΔP^{2003}	3.69	ΔP^{2003}	−0.01
ΔP^{2004}	3.47	ΔP^{2004}	0.55
ΔP^{2005}	3.79	ΔP^{2005}	0.86
ΔP^{2006}	2.86	ΔP^{2006}	1.10
ΔP^{2007}	3.87	ΔP^{2007}	1.02
ΔQ^{2003}	0.04	ΔQ^{2003}	−0.01
ΔQ^{2004}	0.06	ΔQ^{2004}	0.00
ΔQ^{2005}	0.08	ΔQ^{2005}	0.01
ΔQ^{2006}	0.11	ΔQ^{2006}	0.03
ΔQ^{2007}	0.10	ΔQ^{2007}	0.02
ΔPS	123,618,306.10	ΔPS	26,505,692.01
Benefit-cost ratio	6.73	Benefit-cost ratio	1.49
Supply Elasticity = 1.0			
ΔP^{2003}	2.59	ΔP^{2003}	0.17
ΔP^{2004}	2.34	ΔP^{2004}	0.53
ΔP^{2005}	2.48	ΔP^{2005}	0.72
ΔP^{2006}	1.82	ΔP^{2006}	0.84
ΔP^{2007}	2.49	ΔP^{2007}	0.81
ΔQ^{2003}	0.06	ΔQ^{2003}	−0.01
ΔQ^{2004}	0.07	ΔQ^{2004}	0.00
ΔQ^{2005}	0.10	ΔQ^{2005}	0.01
ΔQ^{2006}	0.12	ΔQ^{2006}	0.03
ΔQ^{2007}	0.11	ΔQ^{2007}	0.02
ΔPS	81,911,011.99	ΔPS	22,447,492.78
Benefit-cost ratio	4.43	Benefit-cost ratio	1.26
Supply Elasticity = 2.0			
ΔP^{2003}	1.74	ΔP^{2003}	0.30
ΔP^{2004}	1.55	ΔP^{2004}	0.52
ΔP^{2005}	1.60	ΔP^{2005}	0.62
ΔP^{2006}	1.20	ΔP^{2006}	0.68
ΔP^{2007}	1.59	ΔP^{2007}	0.67
ΔQ^{2003}	0.07	ΔQ^{2003}	−0.01
ΔQ^{2004}	0.08	ΔQ^{2004}	0.00
ΔQ^{2005}	0.11	ΔQ^{2005}	0.01
ΔQ^{2006}	0.13	ΔQ^{2006}	0.03
ΔQ^{2007}	0.13	ΔQ^{2007}	0.02
ΔPS	53,847,986.33	ΔPS	20,021,232.90
Benefit-cost ratio	2.90	Benefit-cost ratio	1.12

6. DEMAND ANALYSIS AT THE RETAIL LEVEL

This section presents analysis of sales (demand) for avocados at the retail account level. Due to an inability to obtain disaggregate expenditures for HAB, CAIA, and MHAIA, this analysis is based on the effects of CAC's promotion program on retail sales of avocados.

6.1. The Data

The data used in the demand analysis at the retail level include scanner data on retail prices and sales for avocados and CAC promotion data on advertising plans and expenditures. Retailer scanner data for this study were acquired from IRI (Information Resources, Inc.) by CAC for two periods: August 4, 2002, to October 31, 2004, (Panel I) and November 12, 2006, to November 2, 2008 (Panel II). The data have a panel structure that combines retail account and size (e.g., small avocados sold at one San Francisco retail chain as a cross-section unit and with a week-long time period). A "retail account" refers to a particular market-retail chain combination, such as Safeway in San Francisco. There are 51 retail chains in panel I and 43 in panel II. A complete data series of a cross-section unit without missing values has 118 weekly observations for panel I and 104 for panel II. The retailer scanner data set contains weekly sales volumes in units, dollar values of sales, and retail prices in dollars per unit for different sizes and varieties of avocados. Panel 1 includes 90 major retail accounts across 38 retail markets in 26 states/regions of the United States. Panel II includes 78 major retail accounts across 41 retail markets in 29 states/regions of the United States.

Retail prices and sales are recorded by price look-up (PLU) codes that identify the size and variety of the avocados sold at retail. However, the origin of the avocados is not identified. There are three PLU codes (4470, 4225, and 4046) for the size (extra large, large, and small) of Hass avocados and four PLU codes for other varieties of avocados. These four-digit PLU codes are for conventionally grown avocados; organically grown avocados are coded by adding a "9" in front of the regular four-digit PLU codes. This study focuses on large and small sizes of conventionally grown Hass avocados that were carried by most of the retail accounts and comprised more than 90% of the total category sales in the data. There are many missing values for the other PLU codes, including extra large Hass avocados, which were not consistently carried by retailers. Hereafter, "avocados" refers to Hass avocados. Table 8 provides the summary statistics for the disaggregate data.

CAC provided information on media types, geographic locations, timing, and expenditures for the advertising programs that it conducted during the 2003 and 2004 marketing years. The media types used in CAC's promotion programs are radio advertising, outdoor displays, and magazine advertising. CAC's advertising programs were conducted in eleven or twelve selected markets during late January or early February to July each year. These same markets have been chosen for CAC's advertising programs for more than ten years. They are Los Angeles, San Diego, San Francisco, Sacramento, Phoenix, Dallas, San Antonio, Houston, Denver, Portland, Seattle, and Atlanta. The markets were selected by CAC because they represent areas with high rates of avocado sales per capita and are located in states in which avocado imports from Mexico were prohibited until recently. Retail scanner data were available for all promotion markets except San Diego and Sacramento.

CAC provided data on its weekly expenditures on radio and outdoor promotions in each selected promotion market. Radio promotions are conducted four times per year for three-week periods between February and mid-July. Outdoor promotions are held during four-week intervals between radio promotions in all of the selected markets except Atlanta and involve displays of billboards and posters. For example, CAC conducted radio advertising for three weeks from January 26 to February 14, followed by a four-week break without promotion. Radio advertising then resumed for three weeks (from March 7 to 28), was followed by outdoor promotion for four weeks (from March 29 to April 24), and then resumed for another three weeks (starting on April 25). All selected markets have the same time schedule for promotion.

Similar promotion information was available for 2007 and 2008 for radio promotions only. Other CAC programs were conducted continuously and/or at the national level and disaggregate expenditure information is not available. Therefore, those programs cannot be evaluated at the disaggregate level. Furthermore, the retailer scanner data include only seven of the thirteen promotion markets in 2007 and seven of the sixteen promotion markets in 2008. Therefore, given the nature of the available data, the results from panel I are more informative and robust than the results from panel II. In addition, expenditure information was not available at the disaggregate level for MHAIA, CAIA, and HAB to use for promotion evaluation. This omission is more problematic than it might appear. In addition to prohibiting evaluation of the impacts of those expenditures, the missing information represents "missing variables" and their omission may bias estimates of the impact of CAC's expenditures.

6.2. The Econometric Models

The retail sales model was specified in the following form:

$$\begin{aligned} q_{a,s,t} = \; & \alpha + [\delta_1 p_{a,s,t} + \cdots + \delta_p p_{a,s,t-p}] \\ & + \tau Ad_{m,t} \\ & + \alpha_t + \alpha_{a,s} + \varepsilon_{a,s,t} \end{aligned}$$

where $q_{a,s,t}$ is the sales volume in thousands of units for size s (s = {large, small}) avocados at retail account a (e.g., Safeway in Los Angeles) in week t. Retail sales are modeled as a function of the contemporaneous and lagged retail price ($p_{a,s,t} \cdots p_{a,s,t-p}$), advertising expenditure, individual retail account, and time-control variables that include dummy variables for holidays and events.

$Ad_{m,t}$ denotes CAC's advertising expenditures in thousands of dollars in market m in week t. The advertising expenditures are aggregated over expenditures on radio and outdoor promotions during 2003/04

Table 8. **Summary Statistics for the Disaggregate Model**

	Panel I: 2002/03–2003/04		Panel II: 2006/07–2007/08	
Item	**Average**	**Standard Deviation**	**Average**	**Standard Deviation**
Price (cents/unit)				
Large	150.00	39.05	142.25	73.14
Small	118.11	44.35	116.47	41.26
All	131.23	42.41	130.74	45.14
Sales (1,000 units)				
Large	28.38	56.61	51.17	85.52
Small	36.93	91.63	29.70	53.30
All	49.41	94.34	41.19	73.14
Promotion ($1,000/week)				
Radio	27.73	20.26	37.36	22.24
Outdoor	9.95	3.52		
All	19.84	17.99		
Number of markets	38		41	
Number of retail chains	51		43	
Number of retail accounts	90		78	
Number of clusters (account size)	147		142	
Number of observations	13,886		14,166	
Maximum number of observations per cluster	118		104	
Average number of observations per cluster	94		53	

but include only expenditures on radio promotions during 2007/08. Alternatively, expenditures on radio and outdoor promotions can be introduced as separate explanatory variables in Panel I to estimate differential promotion effects for different media types on avocado demand.

Advertising may have a dynamic effect on demand, increasing sales in the current period and into the future. Such effects may be captured by specifying a distributed lag structure for advertising expenditures (Erdem and Keane 1996; Ackerberg 2001, 2003). However, the nature of CAC's promotions made it difficult to apply such models because the weekly expenditure in each treatment market during the promotion periods was essentially constant. As a result, the data do not provide sufficient variations between periods to estimate a distributed lag structure.

We first present a framework for program evaluation based on a binary treatment variable (the presence or absence of a promotion campaign) and then extend this method to the amount of promotion expenditure, which is a continuous treatment variable. When the promotion variable is binary (i.e., advertising is present in the market ($D = 1$) or is absent ($D = 0$)), the approach of Difference in Difference (DID) is used. The fact that CAC selected a subset of markets for its promotion programs from among the total group on which scanner data were available enables us to construct both treatment and control groups for the program evaluation. The DID approach estimates counterfactual outcomes for the retail accounts in the selected markets that were exposed to CAC's promotion programs. The DID framework for identifying the "treatment effects" of CAC's promotions on retail sales can be presented by the following linear model:

$$q(a,t) = \delta(t) + \eta(a) + \psi D(a,t) + \upsilon(a,t)$$

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

Under the assumption that CAC's selection for treatment is not correlated with the error term,[22] we can obtain the difference in expected retail sales with and without CAC's promotions for the retail accounts in the treated and control markets as:

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

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

Notice that the use of a simple comparison of retail sales before and after promotion to evaluate the promotion effect is likely to be biased by temporal trends in retail sales or by factors other than the promotion that occurred during both periods. They are represented in the preceding equations by the term $\delta(1) - \delta(0)$. The DID approach is applied to

[22] The set of markets selected for promotion by CAC and HAB have been quite stable since 1997. They represent cities with large market shares for avocado sales and are located in states in which importation of Mexican avocados had been prohibited historically. Thus, market selection is affected by market-specific characteristics that do not change during the study period and is not correlated with the individual transitory error term. The market-specific characteristics, therefore, can be controlled by fixed effects.

construct a counterfactual against which to measure the promotion effect. Therefore, the treatment effect of CAC's promotion, ψ, can be identified in the following form:

$$\psi = \{E[q(a,1)\,|\,D(a,1) = 1] - E[q(a,0)\,|\,D(a,1) = 1]\} - \{E[q(a,1)\,|\,D(a,1) = 0] - E[q(a,0)\,|\,D(a,1) = 0]\}.$$

Our approach is to measure the promotion variable as a continuous variable consisting of the weekly promotion expenditure for each promotion market. In this case, the before-treatment level is represented by the mean level of retail sales and the after-treatment level is represented by deviation of sales from the mean level. The estimated coefficient of the promotion variable presents the treatment effect of CAC's promotions—that is, the difference in deviations of retail sales from individual means between promotion and nonpromotion markets. The comparison of retail sales between promotion and nonpromotion markets is made by holding average retail sales at the individual retail account level constant. The promotion effects, therefore, can be estimated by a "within" model. The evaluation of promotion effects, then, is based on deviations at the individual chain level. However, average retail sales in promotion markets may also increase as a result of CAC's promotions. We can estimate the effects of the promotion program on average retail sales using a "between effects" model that compares sales in promotion and nonpromotion markets.

In the following, we present results from four econometric models: a pooled model, a within model, a between-effects model, and a random-effects model. The pooled and random-effects models utilize variations over time and in cross-section. The between-effects model uses only variations between individual chains in cross-section. The within model uses deviations over time for the dependent and explanatory variables from their time-averaged values.

6.3. Results

We provide a brief discussion of the overall results for the within model, which are summarized in Table 9. Tables 10 and 11 focus specifically on promotion impacts estimated across several econometric models. The seasonal patterns of retail demand for avocados were quite stable over the study period. Avocado demand did not vary significantly during the same month or the same holiday/event across different years. The estimates for the year indicator or dummy variables show that retail sales grew steadily over the years, a determination that is consistent with results from the aggregate model. Retail sales were greatest during the months of May, June, and July and then began to decline in August or September.

Retail demand for avocados is significantly greater during particular holidays and events. Super Bowl Sunday generated the most sales, followed by Cinco de Mayo, Christmas/New Year's Day, Independence Day, and Labor Day. Retail sales grew significantly over time for Cinco de Mayo with sales growth more than doubling in 2007 and 2008 during that week compared to 2003 and 2004.[23]

The results indicate that retail demand for avocados at the individual chain level is price elastic. The estimated elasticities are −2.034 during 2003/04 and −2.238 during 2007/08.[24] Lagged retail prices had significant and positive effects on retail sales in the current period.[25] However, retail sales responded mainly to changes in the contemporaneous retail price.

[23] Li (2007) demonstrates that retail prices and margins were significantly lower during some holidays/events associated with high demand for avocados (e.g., Christmas/New Year's Day, Super Bowl Sunday, and Cinco de Mayo), indicating that retailers are using avocados as sale items during these periods of peak demand, thereby further stimulating demand.

[24] Note that demand at the level of the individual retail chain is expected to be much more elastic than demand at the market level. High price elasticity at the chain level reflects competition between chains for price-conscious consumers and also the response of both store-loyal consumers and price-conscious consumers to price promotions for avocados. In essence, these estimated elasticities demonstrate that avocados are a product that responds well to price promotions. Due to their perishable nature, they are an effective product for promotions in a second dimension because they cannot be stockpiled by consumers.

[25] This result is also intuitive. Even though avocados are perishable, the estimated impact of lagged prices shows that people are willing and able to defer purchases in period $t-1$, for example, if prices are high in hopes of obtaining a better price in period t.

Table 9. Estimation Results for the Retail Sales Model: Within Model

Dependent Variable: Retail Sales (1,000 units)		Panel I: 2003/04		Panel II: 2007/08	
		Coefficient	Standard Error	Coefficient	Standard Error
Price (cents/unit)	*t*	−0.508***	(0.088)	−0.736***	(0.123)
	t – 1	0.155***	(0.042)	0.252***	(0.096)
	t – 2	0.135***	(0.024)	0.096***	(0.043)
Price elasticity at means	*t*	−2.034	(0.126)	−2.238	(0.140)
	t – 1	1.621	(0.028)	0.764	(0.085)
	t – 2	0.540	(0.009)	0.291	(0.017)
Promotion ($1,000)		0.014	(0.060)	−0.139	(0.080)
Christmas /New Year		7.06***	(1.82)	6.17***	(1.30)
Super Bowl		17.59***	(3.86)	15.94***	(4.52)
Valentine's/Presidents' Day		0.73	(1.21)	−0.43	(2.10)
Oscar Awards		1.29	(1.25)	−4.53*	(2.33)
Cinco de Mayo		4.52**	(2.11)	11.12***	(4.03)
Easter		1.52	(1.40)	−0.74	(1.22)
Mothers' Day		−1.20	(1.50)	−0.44	(1.87)
Memorial Day		2.70*	(1.45)	−1.14	(2.03)
Fathers' Day		−3.52	(3.24)	0.61	(1.87)
Independence Day		4.11***	(1.35)	5.12***	(1.36)
Labor Day		5.19***	(1.70)	2.32***	(0.88)
Thanksgiving		−1.51	(2.93)	−7.42***	(1.88)
2002 (base)		0.0	0.0		
2003		0.97	(1.41)		
2004		4.78**	(2.25)		
2007 (base)				0.0	0.0
2008				2.88	(2.15)
January		−1.53	(1.18)	−0.59	(2.01)
February		−1.60	(1.34)	3.30	(2.67)
March		−0.64	(1.44)	3.69*	(1.95)
April		−0.29	(1.50)	1.71	(1.82)
May		3.68***	(1.39)	8.62***	(2.73)
June		7.74**	(3.16)	5.26**	(2.30)
July		0.00	(1.41)	6.34***	(2.01)
August		1.17	(1.50)	3.85**	(1.49)
September		4.34***	(1.63)	0.06	(1.12)
November		1.57	(1.75)	−0.45	(1.68)
December		−1.21	(1.75)	−6.10***	(1.50)
Constant		−4.11***	(1.35)	90.06	(9.78)
R^2		0.108		0.062	
Number of observations		15,360		13,838	
Maximum no. of observations per cluster		118		104	
Number of clusters		147		142	

Note: Asterisks denote statistical significance levels with one, two, and three stars denoting statistical significance at 90%, 95%, and 99%, respectively.

An alternative model framework included lags of retail sales of a variety of lengths but the lagged sales had no important effects either in terms of magnitude or statistical significance. These results indicate the absence of state dependence in weekly retail sales of avocados, or the absence of a consumption habit effect for avocados, as measured on a weekly basis.[26]

Turning now to promotion, the measured impact of CAC's promotion program on retail sales for avocados is comprised of two effects. First, CAC's promotion may contribute to higher average retail sales in promotion markets relative to nonpromotion markets. However, the estimated coefficient of the promotion variable from the between-effects model consists of both the effect of promotion and the effect of other unobserved factors on average retail sales. These unobserved factors, which may contribute to differences in average retail sales between promotion and nonpromotion markets, need to be controlled to attain clean identification of the effect of promotion.

Second, the effect of the promotion program on retail sales is measured by how much retail sales deviate from mean levels as the promotion expenditure increases or as the promotion program is conducted in a week. This effect is estimated by the within model by controlling the difference in average retail sales between promotion and nonpromotion markets. Clearly, the overall promotion effect includes both the effect on average retail sales and the effect on deviations of retail sales from the average in promotion markets. Both the pooled and the random-effects models utilize variations in promotion both in cross-section and over time to estimate the overall promotion effect. The random-effects model is preferred to the pooled model in the presence of unobserved heterogeneity. Nevertheless, both provide valuable information.

Tables 10 and 11 present the estimated effects of promotion on retail sales by the pooled, between-effects, within, and random-effects models for the data in Panel I and Panel II, respectively. Estimation I, which is reported in the top portion of each table, does not control unobserved factors that may contribute to the difference in average retail sales between promotion and nonpromotion markets. As a result, the estimated promotion effect from the pooled, between-effects, and random-effects models could be biased. Estimation II introduces a dummy variable to control the difference in average retail sales between promotion and nonpromotion markets in the pooled, between-effects, and random-effects models. Estimation III uses dummy variables for individual promotion markets to control differences in average retail sales between each promotion and nonpromotion market.[27]

Consider first the estimates from Panel I, which are shown in Table 10. The estimated promotion effects from the between-effects model show that average weekly retail sales for each size of avocado at retail accounts were 1,472 units greater in promotion markets than in nonpromotion markets for each $1,000 of weekly promotion expenditure (estimation III). The average weekly promotion expenditure was $20,419 in a promotion market. Therefore, average weekly retail sales increased by an estimated 30,057 units for each size of avocado sold at retail accounts in promotion markets. Introducing dummy variables to control unobserved factors that may contribute to differences in average retail sales between promotion and nonpromotion markets reduces the size of the estimated promotion effect significantly (compare the promotion coefficients in estimation I versus estimation III). The introduction of additional variables decreases efficiency in the estimations and increases standard errors. The increase in average retail sales in promotion markets due to promotion is positive but is not statistically significant for estimations II and III.

Second, the results from the within model indicate that sales at a retail account in a promotion market increased slightly as promotion expenditure increased during promotion periods but the effect was not statistically significant.

[26] The other rationale to include lagged retail sales in the model is that serial correlation may exist in retail sales. If that is the case, excluding the lagged retail sales could generate omitted variable bias. This did not appear to be an issue for the estimation. The post-estimation tests show that residuals are not serially correlated and overidentification tests show that the set of variables is exogenous.

[27] In other words, estimation III contains a separate {0,1} indicator variable to identify market-specific effects on sales (see the bottom portion of Table 10).

Table 10. The Effects of Promotion on Retail Sales from Panel I: 2003/04

	Pooled		Between		Within		Random Effects	
	Estimate	Std Error	Estimate	Std Error	Estimate	Std Error	Estimate	Std Error
Estimation I								
Retail price *t*	−0.654***	0.128	−0.701***	0.180	−0.508***	0.088	−0.509***	0.088
t – 1	0.092*	0.052			0.155***	0.042	0.154***	0.042
t – 2	−0.003	0.064			0.135***	0.024	0.134***	0.024
Promotion expenditure	**0.792****	**0.322**	**2.741*****	**1.107**	**0.014**	**0.060**	**0.017**	**0.060**
Small size	−9.959	7.786	−15.059	12.019			−1.077	10.675
R^2	0.115		0.167		0.108		0.072	
Root mean square error	72.811		63.634		32.482		32.482	
Intraclass correlation							0.803	
Λ	0.000				1.000		0.954	
Estimation II								
Retail price *t*	−0.621***	0.116	−0.659***	0.181			−0.509***	0.088
t –1	0.102**	0.051					0.155***	0.042
t –2	0.036	0.056					0.134***	0.024
Promotion expenditure	**0.059**	**0.386**	**0.288**	**1.806**			**0.014*****	**0.060**
Promotion market	**36.510*****	**12.019**	**31.060***	**18.128**			**39.006*****	**11.671**
Small size	−9.245	7.760	−14.782	11.940			−2.000***	10.087
R^2	0.158		0.184				0.141	
Root mean square error	71.016		63.208				32.482	
Intraclass correlation							0.801	
Λ	0.000						0.954	
Estimation III								
Retail price *t*	−0.591***	0.102	−0.581***	0.170			−0.509***	0.088
t – 1	0.116**	0.048					0.155***	0.042
t – 2	0.065	0.045					0.134***	0.024
Promotion expenditure	**0.035**	**0.069**	**1.472**	**3.701**			**0.014**	**0.060**
Promotion market								
Phoenix	16.951	13.343	5.825	26.913			21.829*	12.018
Los Angeles	69.981***	25.560	39.899	67.035			73.630***	25.476
San Francisco	39.372*	23.723	25.232	39.694			40.201*	23.523
Atlanta	−7.070	8.219	−27.905	53.288			−2.742	6.531
Portland	2.226	8.329	−2.324	29.755			3.070	7.553
Dallas	4.710	9.940	−10.090	28.089			9.278	9.572
Houston	48.944*	28.158	35.689	28.709			54.332*	30.497
San Antonio	289.623	196.875	280.932***	38.019			296.148	201.896
Small size	−4.831	7.487	−10.423	10.421			−0.834	8.631
R^2	0.364		0.433				0.355	
RMSE	61.763		54.025				32.482	
Intraclass correlation							0.748	
Λ	0.000						0.946	

Note: Asterisks denote statistical significance levels with one, two, and three stars denoting statistical significance at 90%, 95%, and 99%, respectively.

Table 11. The Effects of Promotion on Retail Sales from Panel II: 2007/08

	Pooled		Between		Within		Random Effects	
	Estimate	Std Error	Estimate	Std Error	Estimate	Std Error	Estimate	Std Error
Estimation I								
Retail price *t*	−0.759***	0.121	−0.272**	0.134	−0.736***	0.123	−0.736***	0.122
t – 1	0.245**	0.097			0.252***	0.096	0.252***	0.096
t – 2	0.083	0.058			0.096**	0.043	0.096**	0.043
Radio expenditure	**1.130*** **	**0.278**	**16.419*** **	**2.167**	**−0.139**	**0.080**	**−0.134***	**0.080**
Small size	−30.349***	11.080	−25.143***	9.686			−29.703***	10.967
R^2	0.117		0.350		0.193		0.100	
Root mean square error	69.867		53.523		31.489		31.706	
Intraclass correlation							0.743	
Λ	0.000				1.000		0.942	
Estimation II								
Retail price *t*	−0.745***	0.117	−0.274**	0.136			−0.736***	0.122
t –1	0.254**	0.100					0.252***	0.096
t –2	0.099*	0.058					0.096**	0.043
Radio expenditure	**0.352*** **	**0.176**	**16.169*** **	**3.608**			**−0.134***	**0.080**
Radio promotion market	**55.327*** **	**12.019**	**1.378**	**16.013**			**−0.405**	**13.922**
Small size	−29.911***	7.760	−25.206**	9.749			−29.705	10.984
R^2	0.236		0.350				0.098	
Root mean square error	64.991		53.716				31.646	
Intraclass correlation							0.744	
Λ	0.000						0.942	
Estimation III								
Retail price *t*	−0.685***	0.102	−0.174	0.123			−0.735***	0.088
t – 1	0.290***	0.048					0.252***	0.042
t – 2	0.163***	0.045					0.097**	0.024
Radio expenditure	**−0.140**	**0.069**	**−22.684**	**36.705**			**−0.136***	**0.060**
Radio market								
Phoenix	49.559***	17.283	93.606	71.562			50.197***	15.955
Los Angeles	118.715***	30.768	298.736	291.426			115.488***	31.392
San Francisco	191.403***	54.709	290.859*	160.341			187.585***	55.119
Atlanta	4.303	16.164	126.789	185.952			−6.675	14.974
Portland	15.702	13.438	40.357	50.450			20.182*	11.263
Dallas	3.562	5.363	74.942	116.306			2.980	5.025
Houston	45.722**	23.012	116.805	115.186			44.471**	30.497
Seattle	17.154	15.017	51.899	62.819			22.606	14.211
Small size	−22.650***	7.558	−21.489**	8.559			−26.449***	8.220
R^2	0.454		0.532				0.448	
RMSE	54.987		46.773				31.646	
Intraclass correlation							0.687	
Λ	0.000						0.933	

Note: Asterisks denote statistical significance levels with one, two, and three stars denoting statistical significance at 90%, 95%, and 99%, respectively.

Third, the estimated promotion effects from the random-effects model were the same as those from the within model after effects of individual promotion markets were controlled in estimation II and III. This suggests that promotion on the whole increased average retail sales for promotion markets over those in nonpromotion markets. Promotion effects from week to week in each promotion market were small. This is likely due to the promotion effects merging over time, increasing average retail sales as a whole. Therefore, the majority of the promotion effect was identified via the between-effects model rather than by the within model.[28] This conclusion is consistent with the results of Erdem and Keane (1996), who were able to apply a distributed lag structure to discern the impact of advertising on detergent sales and concluded that advertising had weak short-run effects but a strong cumulative effect in the long run.

Table 11 presents the estimation results from Panel II (2007/08). First, the estimated promotion effects (estimation II) from the between-effects model show that average weekly retail sales for each size of avocado at retail accounts in promotion markets were 16,169 units greater than those in nonpromotion markets for each $1,000 of average weekly promotion expenditure. The estimated impact of these radio promotions is eleven times greater than the estimated impact of CAC's promotion program (which included both radio and outdoor promotion) during the 2002/03–2003/04 crop years. The average weekly promotion expenditure was $37,360 in a promotion market. Therefore, average weekly retail sales increased by an estimated 604,474 units for each size of avocado sold at retail accounts in promotion markets.

Estimation II controls unobserved factors that may contribute to differences in average retail sales between promotion and nonpromotion markets. The results show that the difference was primarily and significantly explained by the difference in average retail sales due to promotion. These results are different from those for 2003/04 (Table 10), which show that the estimated promotion effects were reduced significantly after controlling the unobserved factors that may account for differences in average sales between promotion and nonpromotion markets.

Estimation III includes dummy variables for each promotion market in the data to control differences in average retail sales between promotion markets. The estimated coefficient for the radio promotion expenditure is negative and not statistically significant in estimation III. This is mostly due to inevitable multicollinearity problems because (1) the radio promotion expenditure is highly collinear with the set of dummy variables for promotion markets and (2) introduction of additional variables decreases estimation efficiency. Nonetheless, the estimated coefficients for promotion markets provide valuable information by identifying the markets in which average retail sales were significantly higher. Note that the estimates may represent some effect of radio programs because the promotion variable is highly correlated with the dummy variables for promotion markets. The estimates also may represent the effect of other promotion programs that are not included in the model due to lack of available data. The coefficient estimates for individual promotion markets are markedly higher for 2007/08 than for 2003/04. The markets associated with the highest average sales in 2007/08 were Los Angeles, Atlanta, San Francisco, Houston, and Phoenix while the highest sales in 2003/04 were San Antonio (data were not available for San Antonio during 2007/08), Los Angeles, Houston, and San Francisco.

Second, the results from the within and random-effects models indicate that radio promotions had an insignificant effect on retail sales during the promotion periods both in terms of the magnitude of the estimated effects and their statistical significance. This may be because the effects of individual radio promotions were consolidated over time and increased average sales in the overall market and/or because the effects of radio programs were blended with the effects of other promotion programs that were conducted but are omitted from the estimation (due to lack of available data), such as programs that were conducted in the treatment cities during 2007/08 by CAIA, MHAIA, and/or HAB.

[28] In results not reported here but available from the authors upon request, we investigated decomposing the impact of CAC's expenditures by media type—radio advertising versus outdoor advertising. Results suggest a greater effectiveness for radio promotions relative to outdoor advertising but the effects were not statistically significant.

Taken together, the results suggest that radio promotion significantly increased average retail sales in promotion markets compared with average retail sales in nonpromotion markets. The estimated promotion effects in 2007/08 are also markedly higher than the promotion effects during 2003/04.

The various models reported in Tables 10 and 11 estimated promotion effects from different perspectives but the most relevant results are those for estimation II from the between-effects model. Those effects are comprised of two elements: a significant increase in sales during the promotion period (the wave) and a sales increase stretched during and beyond the promotion period (level). The results from panels I and II consistently indicate that the second effect (increase in the average level) dominates. The first effect, measured by the within and random-effects models, is small because (1) promotion expenditures did not vary much from week to week and/or (2) because the effects of promotion were carried over time and, hence, the promotion effects were consolidated to increase average retail sales (the average level).

A comparison of the results from estimations I and II suggests that the heterogeneity between promotion and nonpromotion markets needs to be controlled and, hence, that estimation II is preferable to estimation I. The results from estimation III must be viewed with some caution due to the problem of multicollinearity. The value of estimation III is the resulting ability to see comparative or relative promotion effects between markets and between two panel periods rather than having to observe only absolute estimates.

6.4. The Effects of the California Avocado Commission's Promotions on Retail and Shipping-Point Prices

The findings for retail sales for avocados suggest, on balance, that CAC's promotion program had a positive effect on retail sales for avocados. We now seek to determine the impacts, if any, of the program on retail prices and prices at the shipping point. This analysis is conducted only on Panel I during 2003/04 because expenditure data were not available for both radio and outdoor programs during 2007/08.

Table 12 presents the estimated effects of CAC's promotion program on the retail and shipping-point price for avocados. Both models use weekly dummy variables as time-control variables. Panel 1 in Table 12 contains the estimated impact of incremental $1,000 expenditures by CAC in the targeted market while panel 2 estimates the cumulative impact in terms of total expenditure during each of the promotion periods.

If arbitrage at the shipping level is efficient between promotion and nonpromotion markets and between promotion and nonpromotion weeks or periods, CAC's promotion program should have no significant effect on shipping-point (FOB) prices to alternative destination markets. Successful promotions in targeted markets increase demand in those markets, which should cause shippers to expand shipments to those markets relative to nonpromotion markets. This reallocation of supply between markets should continue until the shipping-point prices to all destination markets are equated if arbitrage by shippers is efficient. A similar argument applies to intertemporal arbitrage designed to have shipments in place at destination markets to coincide with promotion periods. The results for the shipping-point price of avocados shown in Table 12 reveal a small positive estimated impact of promotion on prices to target markets. Shipping-point prices to promotion markets during promotion periods were 0.116¢ per unit higher (panel 2) than shipping-point prices during nonpromotion periods and to nonpromotion markets. However, this estimated impact is not statistically significant for either radio or outdoor promotion by CAC, which is consistent with the efficient arbitrage hypothesis.

A possible concern for industry generic promotion relates to retailer responses to promotions. Successful promotions targeted to consumers increase demand for avocados. That increase in demand can be reflected in increased retail sales, higher retail prices, or a combination of both. To the extent that retailers increase prices and margins to capture the higher demand generated by industry promotions, their actions vitiate the effectiveness of the programs from the industry's perspective. The increase in sales that is necessary to increase the price received by growers and shippers will not occur. Conversely, if retailers did not capture the benefits of increases in demand for avocados due to CAC's promotion program through higher prices, we would expect the benefit to accrue at the grower-shipper level in the form of higher FOB prices.

An interesting possibility supported by some research is that retailers may *reduce* retail prices in response to a positive demand shock for a product, most likely as a way to entice customers to the store to then purchase additional items. Evidence of lower retail prices for avocados in response to CAC's promotion program would mean that retailers' actions are reinforcing (instead of offsetting) the impacts of CAC's promotion. The results in Table 12 show that retail prices during promotions were 0.363¢ (0.405¢) per unit lower than retail prices in nonpromotion periods and in nonpromotion markets in 2003 (2004). But the effect is not statistically significant due to the insignificance of the promotion coefficient.[29] Thus, there is no evidence that retailers capture some of the demand expansion induced by CAC promotion through higher retail prices and some very weak evidence that they may contribute to the effectiveness of the program by lowering prices to support industry promotions.

Table 12. **The Effects of California Avocado Commission Promotions on Retail Price and Shipping-Point Price**

1. Estimation Results

		Retail Price (cents/unit, weekly)		Shipping-Point Price (cents/unit, weekly)	
		Estimate	Standard Error	Estimate	Standard Error
Promotion (pooled)		−0.019	0.020	0.006	0.024
Radio	−0.019	0.021	0.028	0.018	
Outdoor	−0.023	0.079	0.083	0.062	

2. The Estimated Effects of CAC's Promotion during 2003/04

		Retail Price (cents/unit, weekly)		Shipping-Point Price (cents/unit, weekly)	
		2003	2004	2003	2004
Radio	Radio 1	−0.369	−0.396	0.553	0.592
	Radio 2	−0.396	−0.402	0.593	0.602
	Radio 3	−0.382	−0.387	0.571	0.579
	Radio 4	−0.240	−0.364	0.359	0.545
	Average	−0.347	−0.387	0.519	0.580
Average					
	Radio	−0.275	−0.303	0.147	0.161
	Outdoor	−0.159	−0.167	0.085	0.089
	Promotion	−0.363	−0.405	0.116	0.130

Note: Asterisks denote statistical significance levels with one, two, and three stars denoting statistical significance at 90%, 95%, and 99%, respectively.

[29] These effects are found by multiplying the estimated coefficient on pooled promotion contained in the top half of the table by the mean promotional expenditure in the targeted markets.

7. EVALUATION OF THE HASS AVOCADO BOARD'S NETWORK MARKETING CENTER PROGRAM

HAB conducts an active internet information program through its Network Marketing Center to share information to promote orderly marketing. As stated in its first annual report (2003):

> The primary goal behind the INFOTECH plank of HAB's Strategy is to develop "Strategic Intelligence" that will enable avocado marketers to share information essential to orderly marketing throughout the full 12-month season and ameliorate seasonal transition points and concomitant market instability between sources. This initiative is designed to help ALL sellers in the U.S. market develop a much-needed framework to ensure orderly flow of fruit and market stability. The benefits from such an end state would inure to consumers, supermarket retailers and those suppliers selling Hass avocados in the U.S. (p. 11–12)

All participants in the Hass avocado marketing chain have access to the HAB website (*AvoHQ.com*) where they are able to share harvest and shipment planning information. The 2006/07 annual report (page 3) indicates that HAB's technology infrastructure supported more than 2,500 users and use has continued to grow since then. This ongoing information exchange is intended to smooth shipments to major U.S. markets, prevent surplus and shortage situations, and promote stable FOB and retail pricing.

7.1. Variability of Prices and Quantities over Time

Empirical evaluation of the benefits of an information program is difficult and the activities of HAB are no exception. We can, however, examine some industry statistics related to HAB's goal of an orderly flow of fruit and market stability that provide an indication of progress toward meeting program goals. We measure the variability of prices and quantities over time using the standard deviation of weekly prices and quantities for California and imported avocados. We first examined the standard deviation of California FOB avocado prices for the most recent ten-year period (1998–2007). While there was not an evident trend over time, the weekly standard deviation of the FOB price for the most recent five years averaged 0.2045 while the same average for the first five years was 0.2843. At the same time, the weekly standard deviation of California shipments increased from an annual average of 2,293,841 pounds for the first five years (1998–2002) to 4,303,944 pounds for the most recent five years (2003–2007). This indicates that, while the size of California shipments has become more variable, efforts to coordinate imports with California shipments have smoothed total weekly avocado shipments and prices during the marketing year. The most recent five-year comparison of California shipments with total weekly shipments (California plus imports) is shown in Table 13. While rising imports have the potential to introduce additional quantities and price variability into the U.S. market, the opposite has occurred. Imports have been timed to maintain a rather steady flow of avocados to retail markets, which tends to stabilize prices at both the FOB and the retail level. A portion of the smoothing of quantities and prices despite significantly increased imports can and should be attributed to the active HAB information program.

Previous research on specialty agricultural commodities has demonstrated that decreased price variability can benefit both producers and consumers.

Table 13. **Standard Deviation of Weekly California and Total Avocado Shipments, 2003–2007**

Year	California	Total: California Plus Imports
2003	3,359,560	1,479,939
2004	5,020,240	2,693,992
2005	4,593,614	2,052,438
2006	6,399,061	3,330,162
2007	3,483,128	1,990,026
Five-year average	4,303,944	2,309,312

Market conditions present in the U.S. avocado industry that can lead to this result are: (1) food retailers that have market power in setting their retail prices, (2) a perishable product, and (3) retail chains that purchase the product directly from grower-shippers with operations that are small relative to the chain buyers. Under these conditions, buyers can use large or temporarily large supplies to bid down shipping-point prices and increase their margins (Sexton and Zhang 1996). These same conditions can also lead to asymmetric price transmission from the producer to the retail level as evidenced by retail prices responding more quickly and more fully to FOB price increases than to FOB price decreases.[30]

Li (2007) analyzed the price transmission process for avocados for increases and decreases in shipping-point prices. She summarized the results of her extensive analysis of asymmetric price adjustments for California avocados as follows:

> The [retail] price adjustment rates were 76% to an increase in shipping price and 29% to a decrease in shipping price, and the adjustment was made slower in response to an increase in shipping price than to a decrease in shipping price. Asymmetry in price adjustment to changes in shipping price suggests that retailers were able to manipulate price adjustments to increases and decreases in shipping price to attain higher profits. (p. 333)

Thus, retail prices for avocados respond more fully to shipping-point price increases than to shipping-point price decreases. As a result, retail price margins for avocados tend to increase with larger and more frequent price changes or decrease with smaller and less frequent price changes. Price instability promotes higher retailer margins at the expense of both producers and consumers while increased price stability tends to decrease annual average retailer margins with benefits flowing to both producers and consumers. Thus, information programs that smooth the flow of avocados to U.S. markets and the price of those avocados benefit both producers and consumers.

7.2. Costs of the Hass Avocado Board's Information Program

The annual costs of HAB's information program are listed by category in each HAB annual report (2003–2007) and are summarized in Table 14. Annual expenditures for the information program ranged from $340,179 to $1,090,228 over five years with an average annual cost of just under $750,000. Total five-year costs for the categories of information, analysis, and the Network Marketing Center fell in a rather tight range of $530,514 to $536,936. Almost 57% of the total cost for the first five years ($2,125,915) was in the interaction category.

Table 14. **Annual and Total Costs of the Hass Avocado Board's Information Programs by Cost Category,** 2003–2007

	Year					
Cost Category	**2003**	**2004**	**2005**	**2006**	**2007**	**Grand Total**
Information	$28,619	$219,553	$71,104	$123,434	$94,226	$536,936
Analysis	$0	$44,843	$168,976	$197,375	$120,281	$531,475
Interaction	$286,560	$658,956	$378,566	$404,241	$397,592	$2,125,915
Network marketing center	$0	$166,876	$66,163	$179,052	$118,423	$530,514
Total information	$340,179	$1,090,228	$684,809	$904,102	$730,522	$3,749,840

Source: Hass Avocado Board annual reports, 2003–2007.

[30] Studies that have found asymmetry in price transmission for food products include Kinnucan and Forker (1987) for dairy products; Pick, Karrenbrock, and Carman (1990) for citrus; Zhang, Fletcher and Carley (1995) for peanuts; and Carman and Sexton (2005) for fluid milk in the western United States.

7.3. Estimated Benefits from the Information Program

We used the results from Li's research on price transmission in the marketing channel to estimate weekly changes in gross marketing margins between the shipping-point price (FOB) and the retail price of avocados. Thus, we assumed that the retail price increased, on average, by 76% of the increase in the shipping-point price and decreased by 29% of the decrease in the shipping-point price. We used the aggregate estimated adjustment without attempting to account for the two to three weeks required for the total price adjustment according to Li's analysis. The changes in estimated gross marketing margins from week to week were based on total weekly shipments, the change in the average weighted shipping-point price per pound for all Hass avocados, and Li's estimated adjustment ratios.

Table 15 shows annual estimated gross changes in marketing margins based on each marketing year's weekly total shipments and weighted weekly average shipping-point prices for Hass avocados. The actual annual standard deviations of weekly Hass avocado shipping-point prices both decrease and increase from year to year, ranging from a high of 0.271 in 2003 (the first year of the information program) to a low of 0.058 in 2006 (a year of record weekly shipments due to a very large California crop). Estimated total changes in marketing margins associated with changes in the shipping-point price vary from $2,889,059 in 2004 to a little more than $10 million in 2007. Note that total changes in marketing margins are positively related to average weekly shipments and the standard deviation of weekly prices during the marketing year.

The standard deviation of weekly prices reported in Table 15 measures actual price variability but we also require an estimate of how different this variability would have been without HAB's information program. In other words, has price variability been reduced by the HAB information program and, if so, by how much? Our approach was to compare the variability of prices immediately before and after initiation of the information program. A limitation of this approach is that the entire change in price variability is attributed to the information program even if there were other factors that contributed to it.

As noted, the standard deviation of annual California Hass avocado prices decreased from an annual average of 0.2843 for 1998–2002 to an annual average of 0.2045 for 2003–2007. This decrease of 28% in price variability is used as the maximum reduction in price variability due to HAB's information program. The estimated total increase in marketing margins for 2003–2007 as a consequence of price variability is $31,661,000 (from Table 15). Considering that this figure represents the reduced value from the presence of the information program, the decrease of 28% in margins would have been worth a five-year (undiscounted) total of $12.3 million in terms of reduced margin that is reflected in both lower retail consumer prices and higher prices to growers at the shipping point.[31]

Table 15. **Estimated Total Annual Changes in Gross Margins for Hass Avocados, Average Shipments, Standard Deviations of Price, and Average Prices for 2003–2007**

	Year				
Item Estimate	**2003**	**2004**	**2005**	**2006**	**2007**
Margin change ($)	6,533,780	2,889,059	8,133,135	4,033,952	10,070,172
Average weekly shipments (pounds)	8,512,807	11,771,751	12,484,837	15,194,896	13,361,154
Standard deviation of price ($/pound)	0.271	0.128	0.216	0.058	0.263
Average weighted price ($/pound)	1.136	1.018	0.955	0.761	0.993

31 Let M_0 denote the increase in margin due to price variability in the absence of the HAB program and M_1 = 31,661,000 equal the value in the presence of the program. We then have $(M_0 - M_1) / M_0 = 0.28$. Solving for M_1 and subtracting M_0 from it yields $12.3 million.

The division of the total benefit, as well as the assessment cost to fund the information program, between consumers and producers depends on the value of consumers' price elasticity of demand, ε_D, relative to producers' price elasticity of supply, ε_S, for avocados to the U.S. market. As noted in section 5, we have good estimates of ε_D from the econometric analysis in section 4 but lack a reliable method by which to estimate ε_S in the current market environment. Thus, section 5 reported benefit-cost ratios for alternative values of ε_S of 0.5, 1.0, and 2.0. The share of a change in margin going to consumers in terms of lower price is

$$\Delta P = \frac{\varepsilon_S}{\varepsilon_S - \varepsilon_D} .$$

For purposes of this calculation, we computed ε_D at the average of price and quantity for the past ten years. Although the estimates vary depending on the specific econometric model estimated, all produced a value of $\varepsilon_D \approx -0.25$ during this period. Thus, the producers' share of the benefit and the cost from the information program varies from about 11% to 33% depending on the value assumed for ε_S. Assuming that the entire margin reduction can be attributed to HAB's information program, the total net benefit is the $12.3 million gross benefit minus the $3.75 million program cost, resulting in $8.55 million of net benefit. Producers' share of this net benefit is then in the range of $0.94 to $2.82 million dollars with the remainder of the net benefit going to U.S. avocado consumers.

8. CONCLUSIONS

This study has focused on the impact of HAB promotion programs on demand for avocados. The estimated elasticity of promotion ranged from a high of 0.37 to a low of 0.15 depending on model specification. It appears that the trend variables accounted not only for the effects of "tastes and preferences" but also for some of the effects of promotion. Thus, the low estimate of the promotion elasticity is undoubtedly too low and is viewed as conservative.

Simulations of benefit-cost ratios using the highest and lowest estimated promotion response and supply elasticities of 0.5, 1.0, and 2.0 indicate that producer-funded promotion programs not only expanded demand for avocados but provided a positive return on funds spent. The estimated benefit-cost ratios range from 1.12 to 6.73. More importantly, each exceeds 1.0, meaning that (1) the promotion programs supported by HAB during its first five years yielded net benefits to producers and (2) the programs could have been profitably expanded during the 2003–2007 period of analysis. Given the range of promotion and supply elasticities used for the simulations, our best estimate of the benefit-cost ratio for HAB promotion programs is somewhere in the middle of the simulated range of 1.12 to 6.73—most likely, in an interval between 2.5 and 4.0.

The orderly marketing objective of HAB's information program implies a smooth matching of weekly supply and demand with stable prices. Both producers and consumers benefit from price stability when retail prices respond more to FOB price increases than to price decreases as occurs with avocados. A comparison of weekly avocado prices for the five years preceding the creation of HAB with the first five years of its operation shows that price variability decreased an average of 28%. Estimated total producer and consumer benefits from HAB's information program may have been as much as $12.3 million. Subtracting $3.75 million for program costs leaves a net benefit of $8.55 million. Producers' share of this net benefit is estimated to be in the range of $0.94 to $2.82 million with the remainder of the net benefit going to U.S. avocado consumers.

Analysis of avocado promotion programs in major retail markets suggests that radio promotion significantly increased average retail sales in promotion markets over the same sales in nonpromotion markets. Previous results also suggested that radio is a more effective medium than outdoor advertising but the difference in effect was not statistically significant. The opportunity to conduct an evaluation based on available retail scanner data was limited by the industry's inability to systematically provide disaggregate promotion expenditure information.

A potential problem with producer-funded consumer promotion programs is that retailers may respond to increased demand by raising retail prices, thereby curtailing the demand expansion. Analysis of retail pricing behavior for avocados indicates, however, that this does not seem to have occurred systematically and, thus, was not a problem limiting the impact of promotion. Instead, there is weak evidence that retailers may contribute to the effectiveness of the programs by lowering prices to support industry promotions.

REFERENCES

Ackerberg, D.A. "Empirically Distinguishing Informative and Prestige Effects of Advertising." *RAND Journal of Economics* 32 (2001):316–333.

Ackerberg, D.A. "Advertising, Learning, and Consumer Choice in Experience Good Markets: An Empirical Appraisal." *International Economic Review* 44 (2003):1007–1040.

Alston, J.M., J.A. Chalfant, J.E. Christian, E. Meng, and N.E. Piggott. *The California Table Grape Commission's Promotion Program: An Evaluation*. Davis CA: Giannini Foundation of Agricultural Economics Monograph 43, 1997.

Alston, J.M., H.F. Carman, J.A. Chalfant, J.M. Crespi, R.J. Sexton, and R.J. Venner. *The California Prune Board's Promotion Program: An Evaluation*. Davis CA: Giannini Foundation of Agricultural Economics Research Report 344, 1998.

Alston, J.M., J.M. Crespi, H.M. Kaiser, and R.J. Sexton. "The Economics of Commodity Promotion Programs: Summary and Synthesis." *The Economics of Commodity Promotion Programs: Lessons from California*. H.M. Kaiser et al., eds., pp. 387–415. New York NY: Peter Lang Publishing, Inc., 2005.

California Avocado Commission. "Annual Report." Irvine CA, 2003/04–2007/08. Available at www.avocado.org/industry/commission/annual-reports.

California Avocado Commission. "Business Plan." Irvine CA, 2004/05–2006/07. Available at www.avocado.org/industry/commission/annual-reports.

Carman, H.F. "Offsetting Price Impacts from Imports with Generic Advertising and Promotion Programs: The Hass Avocado Promotion and Research Order." *Review of Agricultural Economics* 28(4) (2006):463–481.

Carman, H.F., and R. Cook. "An Assessment of Potential Economic Impacts of Mexican Avocado Imports on the California Industry." *Proceedings of the ISHS XIIIth International Symposium on Horticultural Economics*. Leiden, The Netherlands: International Society for Horticultural Science, 1996, pp. 227–234.

Carman, H.F., and R.K. Craft. *An Economic Evaluation of California Avocado Industry Marketing Programs, 1961–1995*. Davis CA: Giannini Foundation of Agricultural Economics Research Report 345, 1998.

Carman, H.F., and R.D. Green. "Commodity Supply Response to a Producer Financed Advertising Program: The California Avocado Industry." *Agribusiness* 9 (1993):605–621.

Carman, H.F., and R.J. Sexton. "Supermarket Fluid Milk Pricing Practices in the Western United States." *Agribusiness* 21(4) (2005):509–530.

Chilean Avocado Importers' Association. "Annual Financial Statement." Washington DC, 2003–2007.

Cook, R. "The Avocado Market: A Growth Market in a Mature Food Industry." Avocado Brainstorming Session, University California, Davis, Department of Agricultural and Resource Economics, 2003. Available at http://ucce.ucdavis.edu/files/datastore/234-65.ppt.

Crespi, J.M., and R.J. Sexton. "Evaluating the Effectiveness of California Almond Promotion: How Much Did the Litigation Cost Producers?" *The Economics of Commodity Promotion Programs: Lessons from California*. H.M. Kaiser, et al., eds., pp. 167–190. New York NY: Peter Lang Publishing, Inc., 2005.

Erdem, T., and M.P. Keane. "Decision-making under Uncertainty: Capturing Dynamic Brand Choice Processes in Turbulent Consumer Goods Markets." *Marketing Science* 15 (1996):1–20.

Hass Avocado Board. "Annual Report." Irvine CA, 2003–2007.

Hass Avocado Board. "Domestic Marketing Plan." Irvine CA, 2004/05–2006/07.

Kaiser, H.M., J.M. Alston, J.M. Crespi, and R.J. Sexton, eds. *The Economics of Commodity Promotion Programs: Lessons from California*. New York NY: Peter Lang Publishing, Inc., 2005.

Kinnucan, H.W., and O. Forker. "Asymmetry in Farm Retail Price Transmission for Major Dairy Products." *American Journal of Agricultural Economics* 69 (1987):285–292.

Kinnucan, H.W., and Y. Zheng. "National Benefit-cost Estimates for the Dairy, Beef, Pork, and Cotton Promotion Programs." *The Economics of Commodity Promotion Programs: Lessons from California*. H.M. Kaiser, et al., eds., 255–284. New York NY: Peter Lang Publishing, Inc., 2005.

Li, L. "Retailer Pricing Behavior for a Fresh Produce Commodity: The Case of Avocados." Ph.D. dissertation, University of California, Davis, 2007.

Mexican Hass Avocado Importers' Association. "Hass Avocado Marketing Campaign Plan." Prepared by the Preston/Tully Group, Inc., Fallston MD, 2003–2007.

Mexican Hass Avocado Importers' Association. "Letter of Agreement and Budget Allocation between MHAIA and the Preston/Tully Group, Inc." Fallston MD, 2003–2007.

Pick, D., J. Karrenbrock, and H. Carman. "Price Asymmetry and Marketing Margin Behavior: An Example for California-Arizona Citrus." *Agribusiness* 6 (1990):75–84.

Sexton, R.J., and M. Zhang. "A Model of Price Determination for Fresh Produce with Application to California Iceberg Lettuce." *American Journal of Agricultural Economics* 78(4) (1996):924–934.

U.S. Department of Agriculture. *Regulatory Impact and Regulatory Flexibility Analyses: The Potential Economic Impact of Expanded Importation of Hass Avocados from Mexico*. Washington DC: Animal and Plant Health Inspection Service, 2001.

U.S. Department of Agriculture. "Proposed Rule to Allow Fresh Hass Avocados Grown in Approved Orchards in Approved Municipalities in Michoacan, Mexico, to Be Imported into All States Year-Round." Animal and Plant Health Inspection Service, APHIS Docket no. 03-022-3, Washington DC, May 19, 2004.

U.S. Department of Agriculture. *Animal and Plant Health Inspection Service. Importation of "Hass" Avocado Fruit* (Persea Americana) *from Mexico: A Risk Analysis*. Washington DC: Animal and Plant Health Inspection Service, Plant Protection and Quarantine, 2003.

U.S. Department of Agriculture, Foreign Agricultural Service. "World Avocado Situation and Outlook" *World Horticultural Trade & U.S. Export Opportunities*. Washington DC, 2005.

Wolfe, K., and C. Ferland. "Estimated Fresh Salsa Market Potential for Georgia and Bordering States." University of Georgia Department of Agricultural and Applied Economics report FR-03-01, 2003. Available at www.agecon.uga.edu/~caed/Salsa Industry.pdf.

Zhang, P., S. Fletcher, and D. Carley. "Peanut Price Transmission Asymmetry in Peanut Butter." *Agribusiness* 11(1) (1995):13–20.

For information on obtaining copies of this publication, see the back cover.

GIANNINI FOUNDATION RESEARCH REPORT SERIES

The Giannini Foundation Research Report Series (ISSN 0899–3068) is designed to communicate research to specific professional audiences interested in applications. The first Research Report was issued in 1961 as No. 246, continuing the numbering of the Giannini Foundation Mimeographed Report Series, which the Research Report replaced.

The Giannini Foundation of Agricultural Economics was founded in 1930 from a grant made by the Bancitaly Corporation to the University of California in tribute to its organizer and past president, Amadeo Peter Giannini of San Francisco. The broad mission of the foundation is to promote and support research and outreach activities in agricultural economics and rural development relevant to California. In line with those goals, the foundation encourages research in various areas of interest to agricultural and resource economists and supports dissemination of research findings to other researchers and to the public. Foundation membership includes agricultural economists (faculty and Cooperative Extension specialists) at the Department of Agricultural and Resource Economics, Davis, and at the Department of Agricultural and Resource Economics, Berkeley. Associate members include forestry economists in the College of Natural Resources, Berkeley, and economists in the Department of Environmental Sciences at Riverside.

This and other Giannini Foundation publications are available in PDF format online at *http://giannini.ucop.edu/publications.htm*. Hard copies of this report may be ordered from University of California Agriculture and Natural Resources Communication Services.

University of California
Agriculture and Natural Resources (ANR)
Communication Services
6701 San Pablo Avenue, 2nd Floor
Oakland, California 94608–1239

Telephone: 800.994.8849 / 510.642.2431
Fax: 510.643.5470
E-mail: *danrcs@ucdavis.edu*

Visit the ANR Communication Services
Web site at *http://anrcatalog.ucdavis.edu*

Visit the Giannini Foundation Web site at *http://giannini.ucop.edu*