AN ECONOMIC EVALUATION OF THE HASS AVOCADO PROMOTION ORDER'S FIRST FIVE YEARS

A REPORT PREPARED FOR THE

HASS AVOCADO BOARD

BY

Hoy F. Carman
Lan Li
Richard J. Sexton[1]

March 30, 2009

---

[1] **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.**

Table of Contents

List of Figures

List of Tables

AN ECONOMIC EVALUATION OF THE HASS AVOCADO PROMOTION ORDER'S FIRST FIVE YEARS

Hoy F. Carman
Lan Li
Richard J. Sexton[2]

The U.S. Department of Agriculture (USDA) requires periodic evaluation of the effectiveness of national promotion programs under its supervision. The Hass Avocado Board (HAB) has been directed by the Agricultural Marketing Service, USDA, to conduct an evaluation of programs undertaken during it its initial five years of operation, from marketing years 2002-03 through 2006-07. This report provides the results of the USDA-mandated evaluation of HAB promotion programs. The evaluation analyzes the impacts of these 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 avocado promotion in California in 1962 to the present.

Following a brief introduction, in section 2 the report discusses the major marketing programs conducted under the auspices of the 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 U.S., 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 promotions on grower price and income and on consumption of avocados, based upon the results of the demand analysis. Section 6 provides an analysis of avocado demand and the impact of promotions based upon retail scanner data. Section 7 presents an exploratory

[2] 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.

analysis of the impacts of the HAB's information sharing and dissemination programs. Section 8 contains recommendations for future data-collection programs that the HAB should consider to facilitate future program evaluations. Finally, section 9 presents brief concluding remarks.

1. Introduction

The United States 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 percent 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 U.S. 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 the creation of the Hass Avocado Promotion, Research and Information Order (HAPRIO) that was approved in a referendum of producers and importers with 86.6 percent support on July 29, 2002.

The HAPRIO became effective on September 9, 2002, with program assessments becoming effective on January 2, 2003. The 12-member Board that administers the program under USDA supervision consists of 7 domestic producers and 5 importers. Appointment of the first Hass Avocado Board (HAB) members on February 12, 2003 initiated activities under the HAPRIO. The mandatory assessment rate is 2.5 cents per pound for all Hass avocados sold in the U.S., and the maximum permitted assessment is 5.0 cents per pound. The HAB is required to rebate 85 percent of domestic assessments to the California Avocado Commission (CAC) and up to 85 percent of importer assessments to importer associations, which use the funds for their own promotion programs. The HAB uses the remaining 15 percent of assessments for its operations, promotion, and information technology programs.

During its first five years of operation, the HAB collected assessments totaling $98.67 million and rebated $77.6 million to country producer organizations, including $38.64 million to the 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 as follows: CAC, $50.98 million; CAIA, $16.71 million; MHAIA, $14.35 million; and HAB, $9.27 million, for an overall total of $91.3 million spent on Hass avocado promotion in the U.S. market.

2. Avocado Promotion Programs

Even though the HAPRIO is only five years old, promotion of avocados in the U.S. market by California producers provides significant program experience to build upon. Using a state marketing order, the California avocado industry conducted generic advertising and promotion programs from 1962 through 1977 and has operated under provisions of the CAC since September 1978. Review of annual reports of the marketing order and commission programs indicates that the California industry spent over $334 million (in 2007 dollars) on advertising, promotion, and related services from initiation of the program in 1962 through 2002.[3] Total promotion expenditures by the California industry, including the 2003 through 2007 HAPRIO

[3] 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, e.g., we refer to November 1, 2002 through October 31, 2003 as 2003.

allocations, were almost $398 million (in 2007 dollars). Additional promotional expenditures in the U.S. market by the HAB, MHAIA, and CAIA from initiation of HAPRIO assessments in 2003 through the end of the 2006-07 marketing year totaled almost 42 million (in 2007 dollars).

Hass avocado promotion programs take many forms. The CAC allocates the majority of its funds for consumer advertising and merchandising/trade promotions.[4] Significant expenditures are also made on foodservice, public relations, nutrition and internet marketing programs. The CAIA contracted with CAC to conduct its marketing/promotion programs for the first four years from inception through the 2006 marketing year. In 2007 the CAIA began conducting its own programs. The 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.[5]

The annual promotional expenditures by country organization are shown in table 1. Note that the California data are for marketing programs only (industry programs and administration are excluded), and HAB data are for marketing communications only (information programs and administration are excluded). All organizational expenditures are reported for Chile and Mexico.

Table 1: U.S. Avocado Promotional 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 prior November 1 to October 31 of the year listed.

[4] The CAC also collects additional funds from the production of California Hass as well as other types of avocados to support its industry programs and other activities.

[5] Information in this section is based upon each of the organizations' annual business or marketing plans and budgets, as available.

2.1. California Avocado Commission Programs

The CAC typically allocates about 70 percent of its revenues from producer assessments to its marketing programs. Consumer advertising is the leading activity in terms of expenditures, with programs conducted in major markets across the U.S. Consumer advertising messages and timing are tailored to individual markets. The demographics for CAC traditional consumer targets include: women and adults 25 to 54 years old, attended or graduated from college, household income $50,000 plus, employed, and Hispanic. In terms of psychographics, the target audience is adventurous and open-minded; interested in home, style and food; health conscious; and someone who enjoys a variety of cuisines. CAC geographic emphasis continues to be on core markets in Western states and developing markets in other regions.[6] Consumer advertising is focused during the period from February through August coinciding 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 TV (Discovery Network, Food Network and Fine Living), print (*Food and Wine*, *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), co-marketing, trade advertising, retail tie-in events, and cooperative advertising. While the main target is supermarket chains and mass retailers, smaller specialty retailers and wholesalers are not overlooked. The CAC's foodservice marketing efforts focus on restaurant operators (including upscale independents and chains, as well as fast-food and casual-dining establishments),

---

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

institutions such as universities, and foodservice influencers including editors, food writers, and trend-setting chefs.

The CAC's health and nutrition research program is designed to work in synergy with its public relations efforts to establish and communicate the health and nutritional benefits of consuming avocados. Research 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 (i.e. pytosterols, carotenoids, glutathione), as well as their health benefits and effects on disease processes. The 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. Consumers place much more creditability on a news story about health and nutrition benefits of consuming a product than they do on advertising with the same message. The CAC's health and nutrition messages are also featured on its website (http://www.avocado.org/health-nutrition/).

2.2. CAIA and MHAIA Programs

The CAIA and MHAIA have a short history relative to the CAC, and information on their programs is limited. The MHAIA conducted advertising/promotion programs for four of the five years in the evaluation period while the CAIA's first independently operated program was conducted in 2007. Beginning with $700,000 of expenditures in 2004, the MHAIA expanded its marketing budget and activities each year through 2007. The MHAIA spent about two-thirds of its 2004 marketing funds on consumer advertising, with 55 percent of total expenditures for radio advertising. Trade advertising, including co-op marketing funds and website expenditures accounted for another 26 percent of total funds. The 2005 MHAIA budget increased to $2.9

million with $1.5 million (52 percent) spent on radio advertising. Importer co-op marketing and public relations accounted for another 31 percent of total funds with the remainder being spent for websites, trade advertising, and administrative functions. With a total 2006 budget of $4.5 million, MHAIA spending on radio advertising increased to over $2.0 million, but radio advertising's total budget share decreased to 45 percent. Importer co-op marketing, public relations, and trade advertising accounted for almost 32 percent of total expenditures in 2006. The other major new expenditure of $498,000 was for a NASCAR sponsorship. With a total 2007 budget of $6,246,500, MHAIA spending on consumer radio advertising increased slightly to $2,040,000 (32.7 percent). With total spending of $1.89 million, the share for importer co-op marketing, public relations, website and in-store advertising was just over 27 percent. Spending on the NASCAR sponsorship and promotion increased to $1,423,500 (22.8 percent).

There is some annual information on CAIA marketing programs while it contracted with the CAC but only aggregate expenditure data for its independent 2007 program. Note also that the CAIA data available are for the period each season when avocados from Chile are exported to the U.S. rather than for the California marketing year. Information for the period August 2003 through February 2004 indicates that the CAIA marketing program conducted by the CAC included radio advertising, public relations, and merchandising. Radio advertising accounted for about 85% of expenditure on all programs. Four 3-week radio campaigns were conducted in 12 selected markets: 8/18-9/8—including Labor Day, 9/29-10/20, 11/10-12/1—including Thanksgiving, and 12/29-1/19/2004—leading up to the Super Bowl.[7] The 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

[7] Thanksgiving, Super Bowl, and Labor Day are holidays shown by Li (2007) to represent periods of high avocado consumption in the U.S.

marketing programs from April 2005 through February 2006 were similar to the previous two years with an emphasis on consumer radio advertising. Rather than four 3-week radio campaigns as previously, the 2005-2006 campaign consisted of three 3-week and two 2-week programs. In 2007, CAIA also included TV ads for both the general and the Hispanic markets, as well as 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). The information technology consists of *AvoHQ.com* Intranet and the Network Marketing Center (NMC), designed to exchange marketing and strategic information from all suppliers of Hass avocados to the U.S. market in order to improve the flow of fruit and maintain orderly marketing conditions. Marketing communications consist of consumer communications, online marketing, trade communications, industry communications and marketing research. Marketing communications' share of the HAB budget has increased over time, as the total HAB budget has increased and as the InfoTech program has become established. While getting established 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 high visibility. The web site avocadocentral.com was established. MarCom became HAB's major expenditure category in 2005, with a budget of almost $2.7million, with $746,000 expended for InfoTech projects.

MarCom's budget increased to almost $3.5million in 2006. Partnering with the Beef

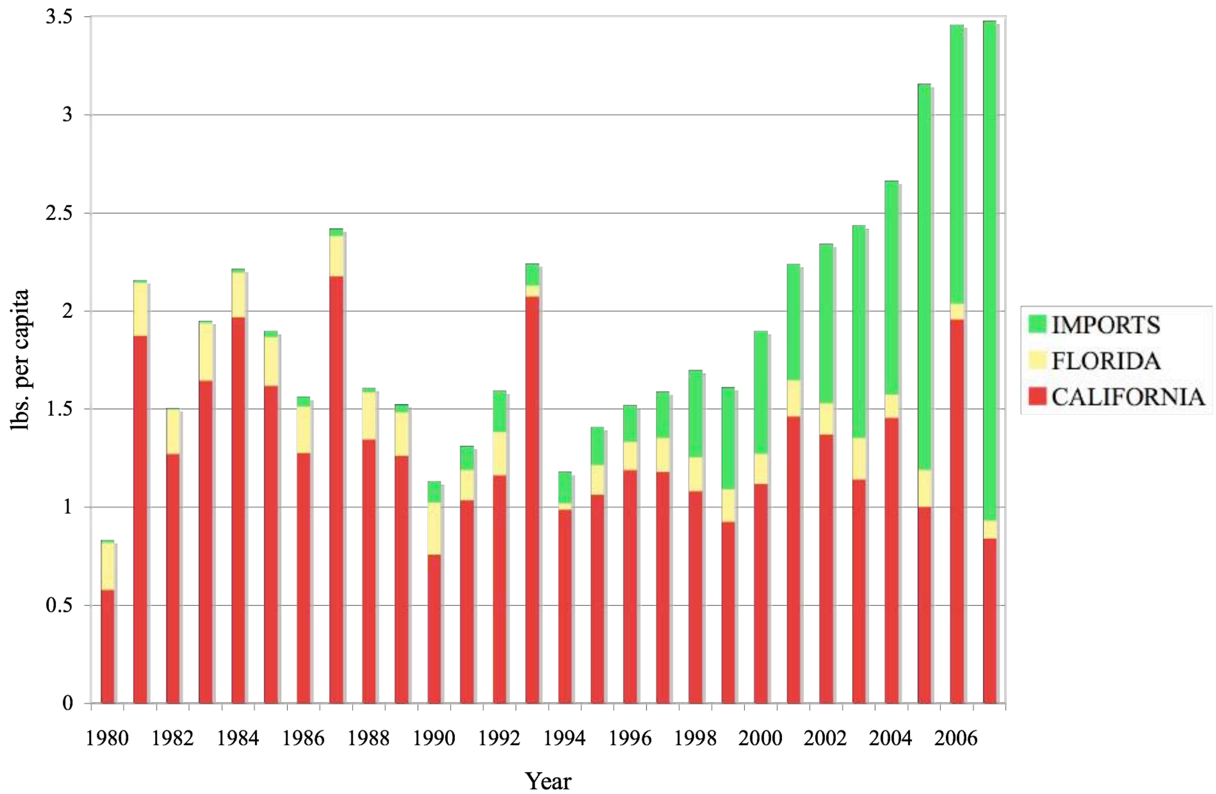
Checkoff and a Napa Valley winery, HAB collaborated to develop a 30-minute television program called "Hot Trends in Tailgating" that was aired on three cable networks (The Food Network, HGTV and Fine Living Network). Six airings of the 30-minute show on each of the three networks was supplemented with 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.

3. Avocado Consumption in the U.S.

U.S. consumption of avocados before 1990 was largely from California production; exports and imports 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 25.0 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 percent of U.S. consumption in 1998 and reached 73.1 percent in 2007. Per capita consumption expanded with increased imports, reaching a record high of 3.45 pounds in 2006 and again in 2007. Estimated U.S. per capita avocado consumption by source of the avocados is shown in Figure 1 from 1980-2007, 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 availability of good-quality avocados in the U.S. year around. 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. As noted, industry promotion budgets have included nutrition programs for several years. Some estimate of impact of these programs is available from CAC tracking studies which show for example "Healthfulness/Good for You" as a reason to purchase avocados increased from 35 to 73% of survey respondents between 1994 and 2004. The industry has made

Figure 1: U.S. Per Capita Avocado Consumption by Source, 1980.



successful efforts to have avocados mentioned specifically as a recommended fruit in diet plans and pyramids, such as the Mediterranean diet pyramid and the Adkins 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 women 25-54 years of age, $50,000 plus income, upscale, college educated, working full/part time, and health conscious. The most frequent uses for avocados are guacamole, part of a Mexican side dish, in a salad, eaten plain, in a sandwich/burger, and as part of a non-Mexican entrée (Cook 2003).

The HAB has sponsored research examining U.S. Hispanic consumers that tends to confirm some widely held industry perceptions, including that Hispanics are "heavy users" of avocados. The HAB reports that Hispanics buy significantly more avocados than the average consumer (2007, p. 12). For the time period tracked, 97 percent of Hispanic shoppers bought avocados as compared to 49 percent of the general population. In addition, 60 percent of Hispanic shoppers purchased avocados weekly, and their average purchase of 4.8 avocados was 58 percent greater than the average overall purchase of 2.8 avocados. 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. U.S.-born Hispanics are more aware of the Hass variety but purchase fewer avocados than do their foreign-born counterparts (p. 13).

4. Modeling the Annual Demand for Avocados

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

4.1. Previous Studies

Carman and Green (1993) estimated price and acreage-response equations as the 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 yielded a price flexibility of demand of -1.16 and an advertising flexibility of demand of 0.15, calculated at mean values.[8] 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 yielded a price flexibility of demand of -1.53 and an advertising flexibility of demand of 0.28, calculated at mean values.

Carman and Craft (1998) estimated both annual and monthly price equations for California avocados in a study of the returns to CAC promotional 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.[9] Carman and Craft 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 upon 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

---

[8] Thus, a one percent increase in advertising expenditures was estimated to increase the California f.o.b. price by 0.15 percent.

[9] The responsiveness of avocado demand to generic advertising found in these prior studies is consistent in magnitude to that found for several other California commodities. Alston et al. 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; and raisins, 0.029 in Japan and 0.133 in UK (pp. 406-07). Kinnucan and Zheng summarize estimated elasticities and benefit-cost estimates for the dairy, beef, pork and cotton promotion programs (pp. 262-63, 270).

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, they used a price elasticity of demand of –0.57 (USDA 2004).[10] USDA APHIS did not consider the possible impacts of advertising and promotion on the 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 increased (Carman 2006, p. 476). This study assumed that the effectiveness of importer promotional 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 studies cited in the preceding subsection included variables for per capita sales, real prices, income, promotional expenditures, and share of Hispanic consumers. Other possible demand-shift variables, such as the prices of possible substitutes and complements for avocados, and factors associated with trends in demand, including 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 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 (2006, p.472). He also examined use of variables to measure increased imports (and, hence,

[10] 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 one percent increase in price causes less than a one percent reduction in the quantity demanded.

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 U.S.,
- Pa_t is the average real f.o.b. (farm) price of California avocados,
- Y_t is real per capita U.S. disposable income,
- A_t is the real total value of avocado advertising and promotion expenditures.
- H_t is the percentage of Hispanics in the total U.S. population.

The consumer price index for all items (1982-1984=1.00) was used to deflate prices, income and promotion expenditures to a constant-dollar basis.[11] Detailed information on each of the variables used in the analysis, including means and standard deviations, is included in table 2. Prior to the creation of the HAPRIO, A_t consisted mainly of expenditures by the CAC.

Hispanics' share of U.S. population increased from 3.7 percent to 15.0 percent during the period of analysis, and U.S. Census Bureau population projections have Hispanics' share of total population steadily increasing to 24.4 percent in 2050. Mexico is the world's largest avocado producer and consumer, with annual per capita avocado consumption recently reported at 8 kg or

[11] Based on the results of previous studies, we do not include prices of substitutes or complements in the demand model for avocados. Some of the previous variables that have been investigated include prices of fresh tomatoes, fresh peppers, and lettuce (Carman 2006). In essence, the lack of importance of these products as a factor in influencing avocado demand means that avocados are a unique product in the diet of most consumers, who are not readily willing to substitute other fresh ingredients in place of avocados in their diets.

about 17.6 pounds, as compared to about 3.5 pounds per capita in the U.S. (USDA, FAS, 2005). With approximately two-thirds of the U.S. Hispanic population from Mexico, the Hispanic population variable is intended to measure demographic change that may be related to avocado demand. The increasing Hispanic share of U.S. population may also act as a proxy for the popularity of Mexican food and Mexican restaurants in the U.S.

Consumer demand is inversely related to the price paid based upon 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—e.g., California avocados generally receive a higher price than avocados from Chile or Mexico. We used the California grower or f.o.b. 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, or

Table 2: Variable Definitions and Summary Statistics

Variable	Definition	Units	Range of Values	Mean Value	St Dev
Qa_t	Annual average per capita U.S. sales of all avocados, (California, Florida and all imports)	pounds per capita	0.39 to 3.48	1.49	0.797
Pa_t	Average annual f.o.b. price of California avocados deflated by the consumer price index (CPI) for all items (1982-1984=1.00)	real cents per pound	14.33 to 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 to 16.26	11.83	2.477
A_t	Annual advertising and promotion expenditures by the CAC, HAB, CAIA, and MHAIA deflated by the CPI for all items (1982-1984=1.00)	millions of real dollars	0.60-7.55 (CAC); 0.86-6.37 (HAB, CAIA, MHAIA)	4.17 (CAC); 4.05 (HAB, CAIA, MHAIA)	1.744 (CAC); 2.333 (HAB, CAIA, MHAIA)
H_t	Hispanic population as a percentage of total U.S. population	percent	3.67 to 15.01	7.85	3.487

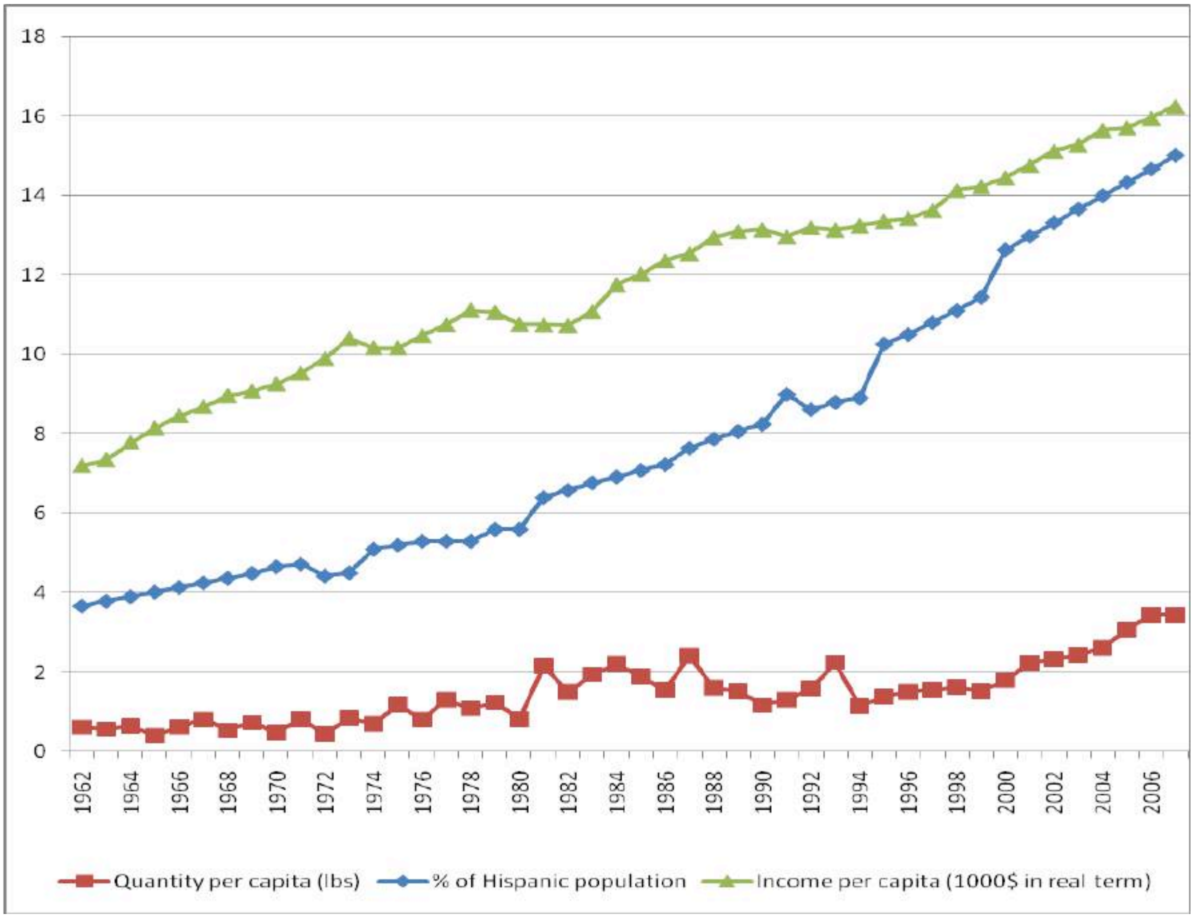
Mexico) and at different stages of the market chain (farm, wholesale, retail) should move in unison as a consequence of the "law of one price", so the specific choice of price series should be of little consequence.[12]

4.3. Preliminary Data Analysis

Before conducting formal econometric analysis, it is important to undertake descriptive studies of the variables being considered for the econometric analysis. A basic problem in conducting 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 U.S. as a function of variables such as real per capita U.S. disposable income (Y_t), real expenditures promoting avocados (A_t), Hispanic share of the U.S. population (H_t), and real California grower price (Pa_t). Figures 2 and 3 illustrate a fundamental challenge. Hispanic population share and per capita disposable income (figure 2) have increased over the time period of the dataset, 1962-2007, in a rather smooth, continuous fashion. Although promotion expenditure 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 f.o.b price (figure 3) is the only one that does not exhibit a significant upward trend.

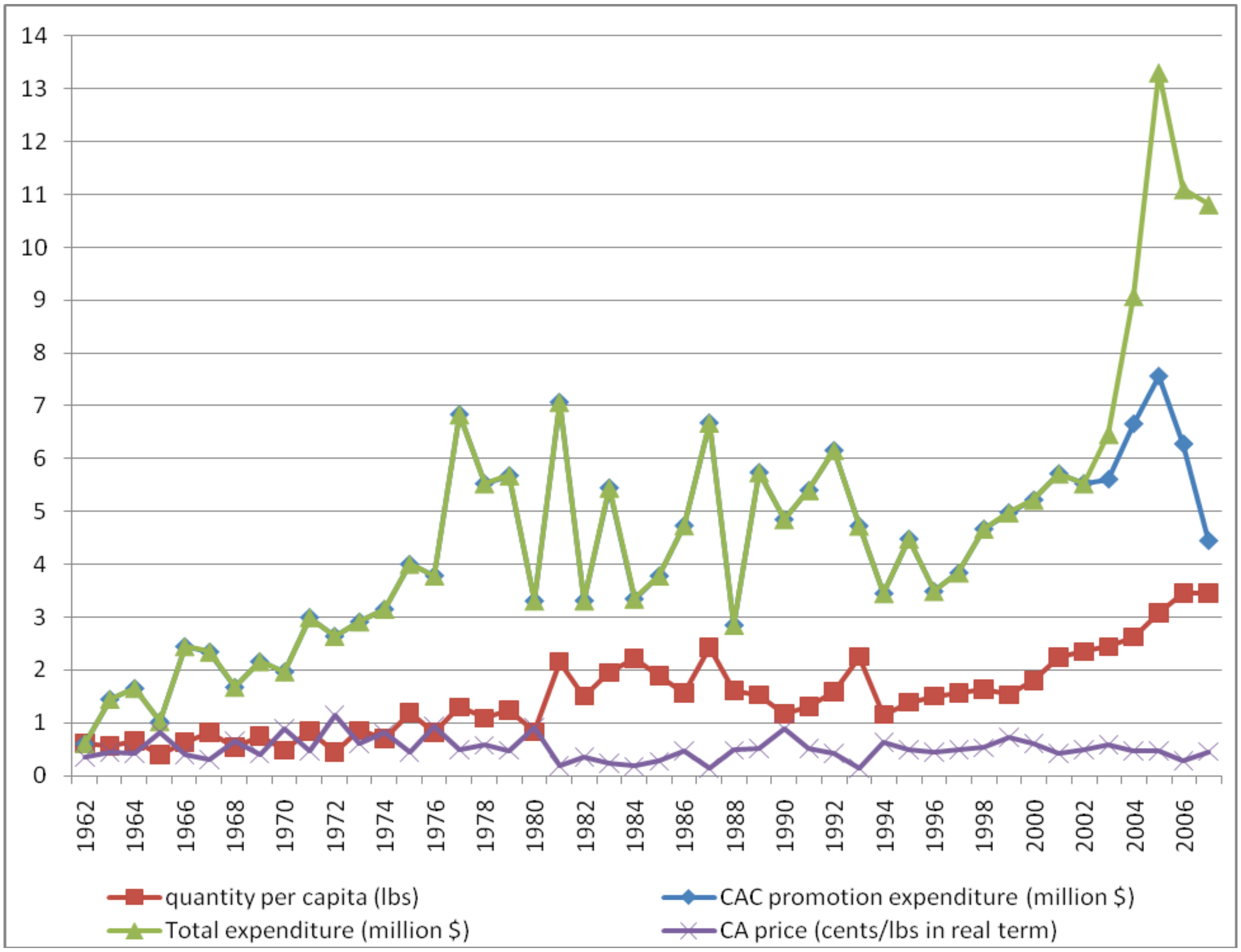
[12] The law of one price follows from basic arbitrage. For example, prices for avocados from different countries of origin may differ for a variety of reasons, such as perceptions of differences in quality, but as long as buyers are willing to substitute among the various offerings, their prices should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

Figure 2: Per Capita Avocado Consumption, U.S. Per Capita Disposable Income, and the Percentage of Hispanic Population



Simple correlation coefficients are a good way to measure co-movement over time of economic variables. Correlation coefficients vary from -1.0 (perfect negative or inverse correlation) to + 1.0 (perfect positive correlation). A value near zero indicates variables that are essentially uncorrelated. Of course, a high positive or negative correlation does not necessarily imply that changes in one variable are "causing" the movements observed in the other variable. It

Figure 3: Per Capita Avocado Consumption, the F.O.B. Price, and Promotion Expenditures



merely means that they move together jointly over time. Examination of table 3 (column 2) reveals that per capita consumption, the variable we seek to explain, is highly correlated with $A_t, H_t,$ and Y_t—these correlation coefficients all range from 0.83 to 0.86. In fact, a simple trend variable, YEAR, constructed by setting its value to 1.0 in the initial year of the data and increasing it by 1.0 each successive year, has a similar correlation with per capita consumption.

Also important to observe is that Y_t and H_t are both highly correlated with YEAR—the correlation coefficients are 0.97 and 0.99 respectively. In essence, this means that over the period of our data, 1962-2007, 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 co-movement, as manifest by correlation coefficients with these three variables ranging from 0.74 to 0.77.[13] This is favorable information, given the purposes of the study, because the independence of movement of A_t creates the potential to

Table 3: Correlation Coefficients for the Demand Model

	Qa_t	Pa_t	YEAR	A_t	H_t	Y_t
Per capita Consumption (Qa_t)	1.0					
Real CA price (Pa_t)	-0.50	1.0				
YEAR	0.83	-0.15	1.0			
Real total promotion Expenditures (A_t)	0.86	-0.25	0.74	1.0		
Hispanic share of Population (H_t)	0.84	-0.15	0.97	0.75	1.0	
Real per capita disposable income (Y_t)	0.83	-0.12	0.99	0.77	0.95	1.0

isolate the impact of promotions on avocado consumption relative to the impacts of the other variables. However, the extremely high correlations among H_t, Y_t, and YEAR mean that there is no opportunity to isolate their individual impacts.

[13]Formal tests for the time-series properties of the model variables were also conducted. These include tests of the null hypothesis that a variable is stationary (i.e., is 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 co-variance stationary, i.e., stationary without a deterministic trend. All other variables, per capita consumption, real promotion expenditure, real per capita disposable income, and percent Hispanic population have a statistically significant trend—as 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 Hispanic population each contain a unit root.

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 the 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 around. 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 is at a higher trajectory than in 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.

4.5. Estimated Annual Demand Relationships

Various demand functions based upon equation (1) were 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 3. All estimations reported in table 3 were conducted via ordinary least squares.

Several conclusions immediately follow from examination of table 3. First, overall explanatory power of the model is very high, as measured by the adjusted R^2 statistic, which measures the proportion of total variation in per capita consumption from 1962-2007 that is "explained" by the variables included in the model. Adjusted R^2 varies from about 0.92 to nearly 0.99 for the alternative models presented in the table.

Second, price is inversely related with per capita consumption in a way that is significant statistically and robust to alternative model specifications.[14] This result is, of course, consistent with prior studies and is simply an affirmation of 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 upon model specification. Thus, demand is in the inelastic range, meaning that a one percent increase in production causes roughly a two percent decrease in the f.o.b. price, other factors constant.[15]

---

[14] Conclusions about statistical significance are based upon the absolute t statistics, which measure the precision of estimates. A larger value for the t statistic indicates greater precision in estimation. For sufficiently large samples, an absolute t statistic greater than about 1.96 allows the researcher to reject with 95 percent confidence a null hypothesis that the true effect is in fact zero.

[15] The estimate of price-inelastic demand is consistent with result from prior studies of avocado demand. The estimate from this study is lower (more inelastic) than prior studies, but this result is consistent with the higher rates of avocado consumption in the U.S., beginning in the 1990s and continuing to the present moving consumption down the demand curve into its more inelastic portions.

Table 4: Estimated Annual Demand Models: Ordinary Least Squares

Variable	Model 1: Base model	Model 2: Base model + trend	Model 3: Model 2 + structural break for 1994-2007	Model 4: Model 3 without YEAR
California f.o.b. price (Pa_t)	-0.0120 (7.48) [-0.414]	-0.0125 (7.32) [-0.431]	-0.0132 (8.69) [-0.455]	-0.0131 (8.66) [-0.451]
Per capita disposable income (Y_t)	0.0739 (1.56) [0.592]	0.1782 (1.43) [1.429]	0.1904 (2.88) [1.526]	0.1389 (3.97) [1.114]
Hispanic share of population (H_t)	0.0609 (1.87)	0.0798 (2.06)	-0.0103 (0.15)	0.2878 (0.56)
Total promotions (A_t)	0.1192 (5.79) [0.372]	0.1110 (4.93) [0.347]	0.0475 (2.04) [0.148]	0.0562 (2.66) [0.176]
YEAR		-0.0230 (0.91)	-0.0001 (0.92)	
YEAR 1994-2007			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.

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 from the prior discussion that each of these three variables is almost perfectly correlated. 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 percent 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, as well as 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 merely due 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, as can be seen in terms of the sensitivity of results for these variables to minor changes in the model specification. Importantly, because our main interest is in evaluating the effect of promotions, this inability to separate impacts due to $Y_t, H_t,$ and YEAR does not constitute a significant limitation on the analysis.

Fourth, promotions have 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 importantly upon 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 dataset. 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 YEAR 1994-2007, which is set to 1.0 in 1994 and 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. YEAR 1994-2007 is positive and statistically significant despite the presence of these other variables.

The one variable in the model that can account, at least partially, for this increase in the consumption trend line is total promotions, which also exhibits an increasing rate of trend beginning about this same time, escalating especially rapidly with the creation of the HAPRIO. Thus, when we introduce separate shift (D1994-2007) and trend (YEAR 1994-2007) variables to account for this evident change in per capita consumption, it eliminates roughly half of the estimated impact of the promotion variable, as comparison of results for Models 1 and 2 with Models 3 and 4 demonstrates. Promotion effects, however, are nonetheless positive and statistically significant even in Models 3 and 4. The estimated elasticity of demand with respect to promotions ranges from 0.148 to 0.372, depending upon 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 the HAB (i.e., expenditures in the last five years) using an annual model. The main problem is that the creation of the HAB was stimulated in large part by the rapid increase of avocado imports into the U.S. and the growing free rider problem caused by importers not contributing to advertising programs funded through the 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 U.S. Any variables created to measure HAB's influence on consumption apart from the general influence over time of promotions as measured by A_t will necessarily capture the rising trend in consumption, much in the way it is captured presently by the variable YEAR 1994-2007 in models 3 and 4. Because the creation of the HAB and the rapid increase in imports and, hence, domestic consumption are, in essence, simultaneous events, 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 price demonstrates that demand grew substantially over this period, at least partially in our view due to promotions.

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 we can have in the estimated results. Details on various diagnostic tests are available from the authors. The ability to attach confidence intervals to estimated effects and conduct statistical tests (such as whether the effect of promotions is statistically different from zero) depends upon the properties of the estimated residuals (actual per capita consumption in year t minus predicted per capita consumption in year t). Tests confirmed that the estimated residuals are homoskedastic (i.e., they have a constant variance) and that they are 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 its presence. A more insidious problem is that serial correlation of the errors may create problems of endogeneity of the explanatory variables.[16] Elimination of serial correlation in the errors may, thus, eliminate some endogeneity problems.

Among the explanatory variables in the model, two are candidates to be endogenous, Pa_t and A_t. The California f.o.b. 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 subject to the check off. Realistically, there is a lag between the realization of production and consumption, the collection of the check-off funds, the preparation of marketing budgets, and the actual expenditures on promotion, making it reasonable that promotion expenditures during year t were determined for the most part by production in year t-1, making A_t exogenous unless errors are serially correlated.

Our strategy was to address the endogeneity of the California f.o.b. 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.

[16] An econometric model suffers from endogeneity if one or more of the explanatory variables is not exogenous, in which case it is correlated with the error term, making the estimated coefficients be inconsistent. Endogeneity is more likely in the presence of serially correlated errors because an explanatory variable whose value in period t was, say, determined 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.

4.7. Two-Stage Least Squares Estimation

The first-stage estimation in the 2SLS procedure involves regressing Pa_t on a set of exogenous instruments. The second-stage involves using the predicted values, $\hat{Pa}_t$, in place of actual Pa_t and re-estimating the annual demand model. Using $\hat{Pa}_t$ in place of Pa_t should eliminate the variable's correlation with the error term.

The key criteria for selection of instruments are that (a) the instruments must be exogenous, and (b) they are correlated with Pa_t. Instruments selected for the stage 1 regression

Table 5: The First-Stage Regression to Predict California f.o.b. Price

Variable	Coefficient (absolute t statistic)
Hispanic share of population (H_t)	-5.7004 (0.46)
Total promotions (A_t)	-5.4186 (2.33)
YEAR	1.8234 (0.58)
YEAR 1994-2007	0.8776 (0.18)
D1994-2007	-1758.741 (0.18)
World import price	0.5355 (2.10)
U.S. avocado acreage	-0.5175 (1.40)
Chilean avocado acreage	0.8209 (0.61)
Mexican avocado acreage	0.0377 (0.15)
Constant	-3523.319 (0.57)

were total U.S. avocado acreage harvested, Chilean avocado acreage harvested, Mexican avocado acreage harvested, and import price for avocados in the world market.[17] Stage 1 regression results are contained in table 5.

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

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

Variable	Model 1	Model 1 + Income
Predicted California farm price $(\hat{P}a_t)$	-0.0117 (5.64)	-0.0109 (3.86)
Per capita disposable income (Y_t)		-0.0698 (0.53)
Total promotions (A_t)	0.0492 (2.34)	0.0527 (2.32)
YEAR	0.0362 (8.20)	0.494 (1.92)
YEAR 1994-2007	0.0964 (5.99)	0.988 (5.86)
D1994-2007	-192.778 (5.99)	-197.587 (5.86)
Constant	-69.899 (1.69)	-95.385 (1.93)
Centered R^2	0.96	0.96

The model shows a small increasing trend in consumption of about 0.036 lbs/year up to 1994, when the trend line spikes upward, increasing at about 0.036 + 0.096 = 0.132 lbs. per

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

capita annually. The promotion effect is positive and statistically significant in both models, but the estimated impact of promotions is reduced due to inclusion of the interaction term for YEAR (trend) and the D1994-2007 dummy variable.

The two-stage least squares models have good statistical properties. [18] We cannot reject that promotion expenditure is exogenous based upon the Sargan statistic. Homoskedasticity of residuals is not rejected based upon 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 upon the Ramsey/Peseran-Taylor Reset test, we cannot reject the null hypothesis that the true relationship among the variables is linear.[19]

4.8. Summary

As illustrated in figures 1 and 4, imports of avocados into the U.S. increased dramatically beginning in the early 1990s and continuing to the present. The evidence from this study and prior studies is that avocado demand in the U.S. is price inelastic, meaning that 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

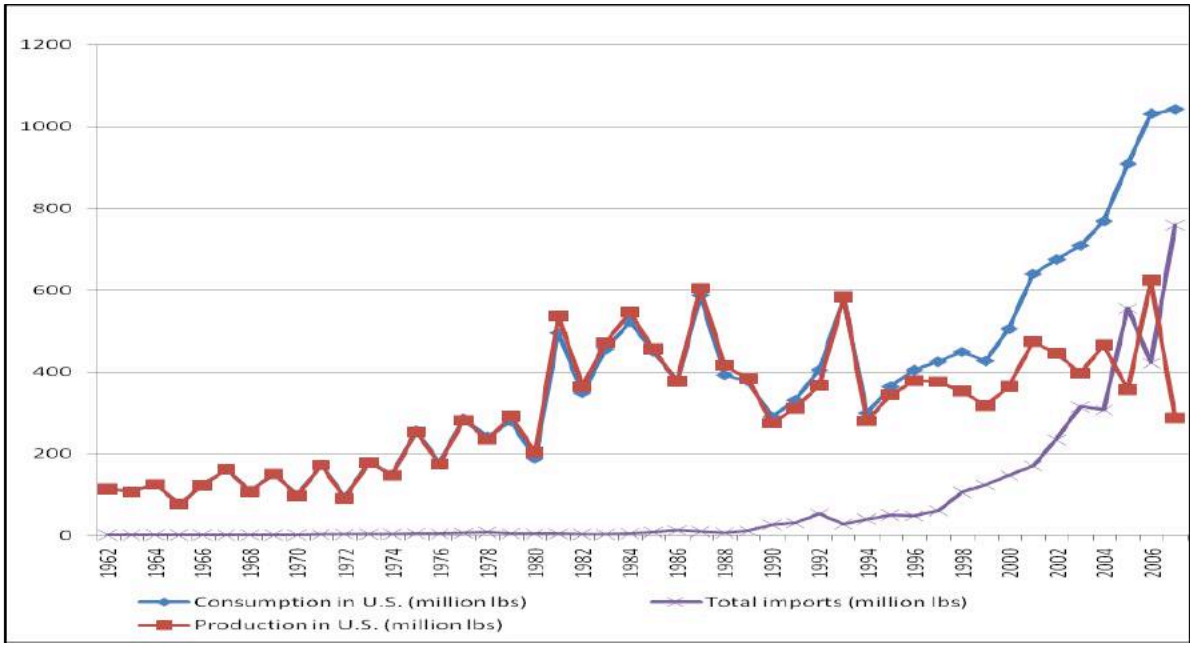
[18] Details on all of the diagnostic tests are available from the authors.

[19] Evaluations of commodity promotion programs often specify a nonlinear effect between promotion expenditure and demand. The economic basis for this specification is that promotions must eventually have diminishing returns, or, 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 expenditures 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, an outcome that is consistent with the results from the Ramsey/Peseran-Taylor Reset test.

that demand has expanded sufficiently to keep real prices relatively stable.[20]

In general, demand for food in the U.S. grows very slowly because, as a high-income nation, most people have sufficient food in their diets, so as their incomes and expenditures

Figure 4: The U.S. Avocado Supply, Imports, and Domestic Production



Notes:

1. The total U.S. avocado consumption is equal to the sum of avocado production in California and Florida, and the total avocado imports, minus total avocado exports (million lbs).
2. The total U.S. avocado production is equal to the sum of avocado production in California and Florida (million lbs).

grow, little of the incremental expenditure goes for food. Unquestionably avocado demand has expanded during this period at a much faster rate than demand for food generally in the U.S. has expanded. The only variable in our model that is capable of explaining the increasing trend line is promotions—e.g., per capita income and Hispanic population share do not exhibit a similar increase in their trend lines.

[20] To be more precise, a regression of real California f.o.b. price from 1994-2007 on a constant and a linear trend results in the following equation: $\hat{P}a_t = 58.86 - 1.095YEAR$. The absolute t statistic on the YEAR coefficient is 1.63. Thus, the real price is estimated to have fallen by about one cent per year, but the effect is not statistically significant at 90 percent or higher confidence levels.

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 U.S. The additional question to ask, however, is whether the promotional expenditures have "paid off" in the sense of yielding benefits to producers from the 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 (BCR) are relevant in promotion-evaluation analysis—average benefit-cost ratios (ABCR) and marginal benefit-cost ratios (MBCR). Producers' 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 costs borne by producers to fund a 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 was successful, with ABCR ≥ 1.0 defining a successful program.[21] The MBCR measures the incremental profit to producers generated from a small expansion or contraction of a promotion program. MBCR answers the question of whether expansion of the promotion program would have increased producer profits, with MBCR > 1.0 indicating a program that could have been profitably expanded.

In general $\text{ABCR} \neq \text{MBCR}$ because promotions are usually modeled as having a nonlinear effect on demand. For example, the square-root function is often used to represent the

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

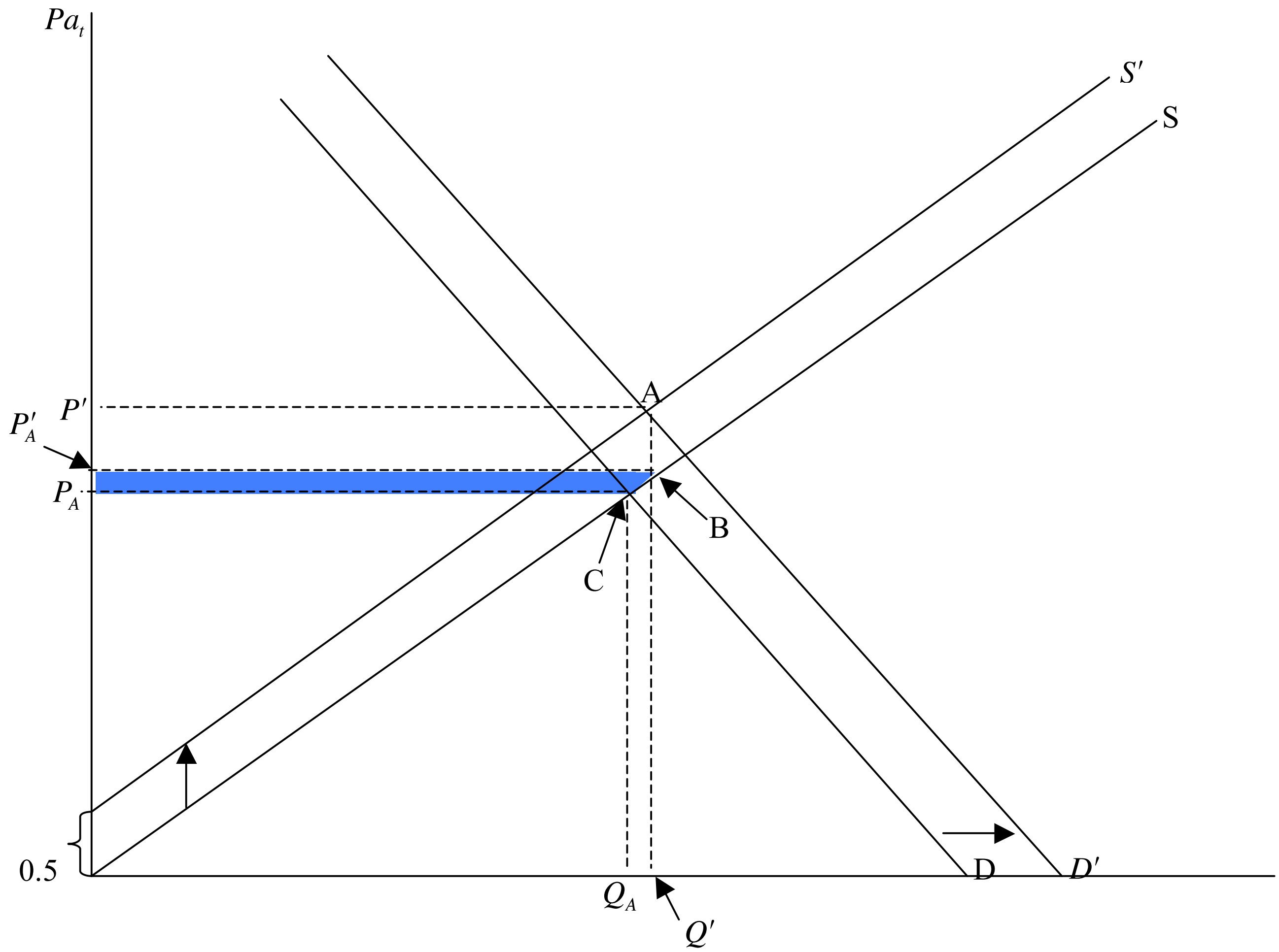
relationship between promotion and demand, and this functional form guarantees a declining effect of marginal promotion dollars on sales (e.g., Alston et al. 1997). Thus, ABCR > MBCR for the square-root model. As discussed in section 4, we utilized a linear model to depict the functional relationship between demand and promotion expenditures, and this relationship was not rejected by econometric tests. For the linear model ABCR = MBCR, and, thus, the two questions “was the program profitable” and “could it have been profitably expanded” are one and the same.

Our strategy was to simulate the impact of a small hypothetical increase in the HAB assessment rate from the current level of $0.025/lb. to $0.03/lb., i.e., an increase of one-half cent per lb., 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, and, 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, as 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 the one-half cent, which shifts supply upward to curve S' as depicted in figure 5.

The additional funds generated by the program expand demand by an amount equal to the incremental funds generated by the assessment times the estimated marginal impact of promotional 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 new market equilibrium is found at the intersection of curves S' and D' at point A in figure 5. Equilibrium price has risen to P' and sales have risen to Q'.

Figure 5: Avocado Promotion Simulation Model



Producer benefits from the hypothetical expansion from the promotion program are measured in terms of producer surplus (PS), which is the same as producer variable profits, i.e., PS = producer price x output – 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, i.e., 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 producer 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: (i) estimates of the marginal impact of promotional expenditures on demand, (ii) estimates of the slope or price elasticity, ε_D, of demand, and (iii) estimates of the slope or price elasticity, ε_S, of supply of avocados to the U.S. market. We have estimates of (i) and (ii) 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—e.g., 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. See Carman and Craft (1998) for discussion of supply response in the California avocado industry. Avocado supply to the U.S. 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 domestic markets and to other export markets. Thus, Chilean and Mexican supply to the U.S. market is a residual supply that is based upon total production and domestic demand in each country and demand from all importing countries except the U.S.

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, and if 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 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 U.S. 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 U.S. due, say, to successful promotions is likely to cause Chilean and Mexican shippers to increase supply into the U.S. Based upon these considerations, we specified three alternative values for ε_S: 0.5, 1.0, and 2.0

Among the available demand models in tables 4 and 6, we selected two: Ordinary least squares model 2 in table 4 and two-stage least squares model 1 in table 6. Both models have good statistical properties, and, because model 2 in 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 were estimated for each year of the 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 intersecting at quantity, Q_A and price P_A in figure 5.[22] Curve S was then shifted vertically to S' by the half cent excise tax and curve D was shifted horizontally to D' by the estimated promotion coefficient times 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 the prior paragraphs.

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 the simulation. For each simulation model, table 7 reports the estimated change in real f.o.b. price in cents/lb. and change in per capita consumption in lbs. 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 three percent real rate of interest. The BC ratio reported in each table is computed by adding the program cost to the net

[22] In other words the demand curve with 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.

benefits to produce gross benefits and dividing gross benefits by total cost.

$$\text{MBCR} = \text{ABCR} = \frac{\Delta \text{PS} + \text{assessment costs}}{\text{assessment costs}}$$

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**
	B/C	**6.73**	B/C	**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**
	B/C	**4.43**	B/C	**1.26**

Table 7: Simulation Model Results (cont.)

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**
	B/C	**2.90**	B/C	**1.12**

Estimated dollar benefits and BC ratio are lower the greater the elasticity of the supply function. This result reflects the important principle that supply expansion in response to promotion-induced demand expansion limits the benefit from the demand expansion because the higher supply attenuates the price increase that would occur in its absence. Estimated dollar benefits and BC ratio are also lower for the two-stage least squares model because that model's estimated promotion coefficient is only 44 percent as great as in the ordinary least squares model 2. The estimated BC ratios range from 1.12 to 6.73, but, importantly, each exceeds 1.0, meaning it is highly likely that (a) the promotional programs supported by the HAB during its first five years yielded net benefits to producers and (b) could have been profitably expanded during the 2003-07 period of analysis.[23] To place these BC ratios in perspective, the most conservative ratio of 1.12 indicates that the 2.5 cents per pound assessment paid by each avocado producer

[23] Note that Carman and Craft's (1998) estimate of the average benefit-cost ratio for CAC's promotion programs was 2.84.

returned 2.8 cents per pound for a net return of 0.3 cents per pound. At the other end of the spectrum (greater demand response to promotion and inelastic supply), the BC ratio of 6.73 indicates that the 2.5 cents per pound assessment returned 16.8 cents per pound for a net return of 14.3 cents per pound.

6. Demand Analysis at the Retail Level

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

6.1. The Data

The data used in demand analysis at the retail level include scanner data on retail prices and sales for avocados and CAC promotional data on advertising plan and expenditure. Retailer scanner data were acquired from Information Resources Inc. (IRI) by the CAC and were obtained from August 4, 2002 to October 31, 2004 (Panel I), and from November 12, 2006 to November 2, 2008 (Panel II) for purposes of conducting this study. The data have the structure of a panel, with a retail account and size combination, e.g., small avocados sold at San Francisco retail chain 1, as a cross-section unit, and with a week as a time period. A "retail account" refers to a particular market-retail chain combination, e.g., Safeway in San Francisco. There are 51 (43) different retail chains in Panel I (II). A complete data series of a cross-section unit without missing values has 118 (104) weekly observations for Panel I (II). Retailer scanner data contain weekly sales volume in units, dollar value of sales, and retail prices in $/unit for different sizes and varieties of avocados for 90 (78) major retail accounts across 38 (41) retail markets in 26 (29) states/regions the U.S. for panel I (II). Retail price and sales are recorded by Price Look-Up (PLU) codes. PLU codes are used to identify the size and variety of avocados sold at retail. However the origin of the avocado is not identified. There are three PLU codes, 4470, 4225, and 4046, for extra large, large, and small sizes of Hass avocados, and four other PLU codes for other varieties of avocados. These four-digit PLU codes are for conventionally grown avocados; the 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 Hass avocados that are conventionally grown, which were carried by most of the retail accounts and accounted for over 90% of the total category sales in the data. There are many missing values for other PLU codes, including extra large Hass avocados, which were not carried by retailers consistently. Hereafter, “avocados” refers to Hass avocados. Table 8 provides the summary statistics on the disaggregate data.

The CAC provided information on media types, geographic locations, timing, and expenditure of the advertising programs it conducted during the 2003 and 2004 marketing years. The media types utilized in the CAC’s promotion programs are radio advertising, outdoor displays, and magazine advertising. The CAC’s advertising programs were conducted in 11 or 12 selected markets during late January or early February to July each year. These same markets have been chosen for the 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 retail scanner data are available for all promotion markets except San Diego and Sacramento.

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

Table 8: Summary Statistics for the Disaggregate Model

Item	Panel I: 2002-2004		Panel II: 2006-2008	
	Average	Std.Dev.	Average	Std.Dev.
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		
# of markets	38		41	
# of retail chains	51		43	
# of retail accounts	90		78	
# of cluster (account-size)	147		142	
# of observations	13886		14166	
Max # of observations per cluster	118		104	
Avg. # of observations per cluster	94		53	

Similar promotion information is also available during the 2007 and 2008 marketing years, but only on radio promotions. Other CAC programs were either conducted with continuous timing and/or at the national level, and disaggregate expenditure information is unavailable. Therefore, those programs can't be evaluated at the disaggregate level. Furthermore, the retailer scanner data include only 7 out of 13 promotion markets in 2007, and 7 out of 16 promotion markets in 2008. Therefore, due to the nature of available data, the results from Panel I are more informative and robust than the results from Panel II. In addition, there are no expenditure data available at the disaggregate level for MHAIA, CAIA, and HAB that can be used for promotion evaluation at the disaggregate level. This omission is more problematic than it might appear; in addition to being unable to evaluate the impacts of those expenditures, they represent "missing variables," and their omission may bias the estimate of the impact of the CAC's expenditures.

6.2. The Econometric Models

The retail sales model was specified in the following form:

$$\begin{aligned} q_{a,s,t} &= \alpha + [\delta_1 p_{a,s,t} + \cdots + \delta_p p_{a,s,t-p}] \\ &+ \tau Ad_{m,t} \\ &+ \alpha_t + \alpha_{a,s} + \varepsilon_{a,s,t} \end{aligned} \quad , \qquad (1)$$

where qa,s,t is the sales volume in thousand 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 contemporaneous and lagged retail prices, $p_{a,s,t}, \ldots p_{a,s,t-p}$, advertising expenditure, individual retail account, and time-control variables including dummy variables for holidays and events.

$Ad_{m,t}$ denotes the CAC's advertising expenditures in \$1,000 in market *m* in week *t*. The advertising expenditures are aggregated over expenditures on radio and outdoor promotions during 2003-2004, and include only expenditures on radio promotions during 2007-2008. Alternatively, expenditures on radio and outdoor promotions can be introduced as separate explanatory variables in Panel I to estimate differential promotional effects of different media types on avocado demand.

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

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

where $q(a,t)$ denotes retail sales of avocados at retail account a at time t. Let the pre-treatment period, $t = 0$, be the period when there was no promotion, and let the treatment period, $t = 1$, be the period when the CAC conducted its promotions. $D(a,t)$ denotes whether a retail account was exposed to the CAC's promotions or not at time t. Suppose that only $q(a,t)$ and $D(a,t)$ are observed. We refer retail accounts that were exposed to the CAC's promotion programs (i.e., $D(a,1) = 1$) as the "treated", and those that were not exposed to the promotions (i.e., $D(a,1) = 0$) as the "controls". $D(a,0)$ equals zero for both the treated and controls, because there was no promotion at $t = 0$. ψ represents the "treatment effects" of the CAC's promotion programs. $\delta(t)$ denotes the time-specific component, $\eta(a)$ represents the account-specific effects, and $\nu(a,t)$ is the individual transitory error term with zero mean at both $t = 0$ and $t = 1$. The advantage of the panel data 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, we can obtain the difference in the expected retail sales with and without the CAC's promotions for the retail accounts in the treated and control markets as

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

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

Notice that the use of a simple comparison of retail sales before and after promotions to evaluate the promotional effects is likely to be biased by temporal trends in retail sales or by factors other than the promotions that occurred during both periods. They are represented in the preceding equations by the term $\delta(1) - \delta(0)$. The DID approach is applied to construct a counterfactual against which to measure the promotional effects. Therefore, the "treatment effects" of the CAC's promotions, ψ, can be identified in the following form:

$$
\begin{aligned}
\psi = \quad & \{E[q(a,1) \mid D(a,1)=1] - E[q(a,0) \mid D(a,1)=1]\} \\
- \; & \{E[q(a,1) \mid D(a,1)=0] - E[q(a,0) \mid D(a,1)=0]\}.
\end{aligned}
$$

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 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 the CAC's promotions, that is, the difference in deviations of retail sales from individual means between promotion and non-promotion markets. The comparison of retail sales between promotion and non-promotion 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. This evaluation of promotion effects is based on deviations of retail sales from individual chain mean levels of retail sales. However, the average retail sales in promotion markets may also increase as a result of the CAC's promotions. We can also estimate the effects of the promotion program on the average retail sales by a "between-effects" model that compares sales in promotion and non-promotion 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 only uses variations between individual chains in cross section. The within model uses deviations over time from their time-averaged values for the dependent and explanatory variables.

6.3. Results

Although the primary purpose of this analysis is to evaluate promotion effectiveness, the demand analysis provides additional insights regarding the characteristics of avocado demand that may be valuable to the industry, so we also 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.[24] The seasonal patterns of retail demand for avocados were quite stable over the study period. Avocado demand did not vary significantly in the same month or in the same holiday/event across different years. The estimates for year indicator or "dummy" variables indicate that retail sales grew steadily over the

[24] Asterisks (stars) are used to denote statistical significance levels, with one, two, and three stars denoting statistical significance at 90 percent, 95 percent, and 99 percent, respectively, for tables 9-12.

years, consistent, of course, with results from the aggregate model. Retail sales were highest during the months of May, June, and July, then began to decline in August or September.

Retail demand for avocados is significantly higher during particular holidays and events. Super Bowl Sunday had the highest sales, followed by Cinco de Mayo, Christmas/New Year, 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 Cinco de Mayo week compared to 2003 and 2004.[25]

The results indicate that retail demand for avocados at the individual chain level is price elastic. The estimated elasticities are -3.006 during 2003-2004 and -2.336 during 2007-2008.[26] Lagged retail prices had significant and positive effects on retail sales in the current period.[27] However, retail sales responded mainly to changes in the contemporaneous retail price.[28]

---

[25] 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, 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.

[26] 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.

[27] 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, say, period t-1 if prices are high in hopes of obtaining a better price in period t.

[28] An alternative model included lags of retail sales, but they had no significant effects. The results indicate the absence of state dependence in weekly retail sales of avocados, or the absence of consumption habit effect for avocados, as measured on a weekly basis.

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

Dependent Variable is Retail Sales (1,000 units)	Panel I: 2003-2004 Coeff.	s.e.	Panel II: 2007-2008 Coeff.	s.e.
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	-3.006		-2.336	
t−1	1.029		0.799	
t−2	0.392		0.304	
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/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)				
2003	0.97	(1.41)		
2004	4.78**	(2.25)		
2007 (base)				
2008			2.88	(2.15)
Jan.	-1.53	(1.18)	-0.59	(2.01)
Feb.	-1.60	(1.34)	3.30	(2.67)
Mar.	-0.64	(1.44)	3.69*	(1.95)
Apr.	-0.29	(1.50)	1.71	(1.82)
May	3.68***	(1.39)	8.62***	(2.73)
Jun.	7.74**	(3.16)	5.26**	(2.30)
Jul.	0.00	(1.41)	6.34***	(2.01)
Aug.	1.17	(1.50)	3.85**	(1.49)
Sep.	4.34***	(1.63)	0.06	(1.12)
Nov.	1.57	(1.75)	-0.45	(1.68)
Dec.	-1.21	(1.75)	-6.10***	(1.50)
Constant	-4.11***	(1.35)	90.06	(9.78)
R^2	0.108		0.062	
# of observations	13886		14166	
Max # of observations per cluster	118		104	
# of clusters	147		142	

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

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

Tables 10 and 11 present the estimated effects of promotions on retail sales by the pooled, between-effects, within, and random-effects models for Panel I and II data, respectively. Estimation I reported in the top portion of each table does not control unobserved factors that may contribute to the average retail sales difference between promotion and non-promotion markets. As a result, the estimated promotion effect from the pooled and between-effects models, and the random-effects model could be biased. Estimation II introduces a dummy variable to control the difference in the average retail sales between promotion and non-promotion markets in the pooled, between-effects, and random-effects model; and estimation III uses dummy variables for individual promotion markets to control differences in average retail sales between each promotion market and non-promotion markets.[29]

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

[29] 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 Promotions on Retail Sales from Panel I: 2003-2004

	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	
RMSE	72.811		63.634		32.482		32.482	
Intra-class 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**
ID 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	
RMSE	71.016		63.208				32.482	
Intra-class 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
Huston	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	
Intra-class correlation							0.748	
Λ	0.000						0.946	

Second, the results from the within model indicate that retail sales at a retail account in a promotion market increased slightly as promotion expenditure increased during promotional periods, but the effect is not statistically significant. Third, the estimated promotion effects from the random-effects model are the same as those from the within model, after effects of individual promotion markets have been controlled in estimation II or III. This suggests that promotions, on the whole increased average retail sales for promotion markets compared with average retail sales for non-promotion markets. Promotion effects from week to week in each promotion market were small. This may be due to the fact that the promotion effects were merged over time, increasing average retail sales on the whole. Therefore, the majority of the promotion effects was identified via the between-effects model compared to the within model.[30]

Table 11 presents the estimation results from Panel II data (2007-08). First, the estimated promotion effects (Estimation II) from the between-effects model show that the average weekly retail sales for each size of avocados at retail accounts in promotion markets were 16,169 units more than the average weekly retail sales in non-promotion markets for each $1,000 of average weekly promotion expenditure. The estimated impact of these radio promotions is eleven times higher than the estimated impact of CAC promotion programs (including both radio and outdoor programs) during 2002-04. The average weekly promotion expenditure was $37,360 in a promotion market. Therefore, the average weekly retail sales increased by an estimated 604,474 units for each size of avocados sold at retail accounts in promotion markets.

Estimation II controls unobserved factors that may contribute to differences in the average retail sales between promotion and non-promotion markets. The results show that the

[30] In results not reported here but available from the authors upon request, we investigated de-composing the impact of the CAC's expenditures by media type—radio advertising versus outdoor advertising. Results suggest a greater effectiveness for radio promotions relative to outdoor advertising, but we caution against attributing undue weight to the result because effects were not statistically significant.

difference in average retail sales between promotion and non-promotion markets was primarily and significantly explained by the difference in average retail sales due to promotions. These results are different from those for 2002-04 (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 non-promotion 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 the radio promotion expenditure is highly collinear with the set of dummy variables for promotion markets, and due to the fact that the introduction of more variables decreases estimation efficiency. Nonetheless, the estimated coefficients for promotion markets provide valuable information as to in which markets the 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, and that the estimates may represent the effect of other promotion programs that are not included in the model due to data availability. The coefficient estimates for individual promotion markets are markedly higher than the estimates during 2003-04. The markets associated with the highest average sales were Los Angeles, Atlanta, San Francisco, Houston, and Phoenix during 2007-08, while the markets were San Antonio (data were not available for San Antonio during 2007-08), Los Angeles, Houston, and San Francisco during 2003-04.

Table 11: The Effects of Promotions 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	
RMSE	69.867		53.523		31.489		31.706	
Intra-class 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**
ID radio 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	
RMSE	64.991		53.716				31.646	
Intra-class 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	
Intra-class correlation							0.687	
Λ	0.000						0.933	

Second, the results from the within model and random-effects model indicate that the radio promotions insignificant effects on retail sales during the periods of the promotion, both in terms of magnitude of the estimated effect and its statistical significance. This may be because the effects of the radio promotions were consolidated over time and increased the overall market average sales, 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 data availability, e.g., any programs that were conducted in the treatment cities during 2007-08 by CAIA, MHAIA, and/or HAB.

Taken together, the results suggest that the radio promotion significantly increased the average retail sales in promotion markets compared with average retail sales in non-promotion 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. Promotion effects estimated from the between-effects model are comprised of two elements, i.e., a significant increase in sales during the promotion period (the wave) and a sales increase stretched during and beyond promotion period (level). The results from both Panel I and II consistently indicate that the second effect, i.e., an increase in the average level, dominate. The first effect measured by within and random-effects is small because: i) promotion expenditures did not vary much from week to week, and/or ii), because the effects of promotion were carried over time, and hence the promotion effects were consolidated to increase average retail sales, i.e., the average level.

Comparison of the results from Estimation I and II suggest that the heterogeneity between promotion and non-promotion markets needs to be controlled, and hence, Estimation II is preferred relative to Estimation I. Estimation II yields the best estimate of average promotion effects across promotion markets, which is one of the main purposes of the present study. Estimation III results must be viewed with some caution due to the problem of multicollinearity. The value of Estimation III is to see comparative or relative promotional effects between markets, and to see comparative promotion effects between markets and between two panel periods, rather than focus on the absolute estimates.

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

The findings on retail sales for avocados suggest on balance that the CAC's promotion programs had positive effects on retail sales for avocados. We now seek to determine impacts, if any, of the programs on retail prices and prices at the shipping point. This analysis is conducted only for Panel I data during 2002-2004, because the expenditure data are available for both radio and outdoor programs.

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

If arbitrage at the shipping level is efficient between promotion and non-promotion markets and between promotion and non-promotion weeks or periods, the CAC's promotion programs should have no significant effects on shipping 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 non-promotion markets. This reallocation of supply between markets should continue until 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 shipping-point price of avocados in table 12 reveal a small positive estimated impact of promotions on shipping prices to target markets. Shipping prices during promotion periods were 0.116 cent/unit higher (panel (b)) than shipping prices during non-promotion periods in promotion markets compared with non-promotion markets. However, this estimated impact is not statistically significant for either CAC radio or outdoor promotions, which is consistent with the efficient arbitrage hypothesis.

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

Table 12: The Effect of the CAC's Promotions on Retail Price and Shipping Price

(a) Estimation Results

	Retail Price (cents/unit, weekly)		Shipping Price (cents/unit, weekly)	
	Estimate	s.e.	Estimate	s.e.
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

(b) The Estimated Effects of the CAC's Promotions during 2003–2004

	Retail Price (cents/unit, weekly)		Shipping 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

An interesting possibility supported by some scholarly 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 in hope that they will purchase additional items. Evidence of lower retail prices for avocados in response to the CAC's promotion programs would mean that retailers' actions were reinforcing (instead of offsetting) the impacts of the CAC' promotions. The results in table 12 show that retail prices were 0.363 (0.405) cent/unit lower, but not statistically significant, than retail prices in non-promotional periods and in non-promotion markets in 2003 (2004). Thus, there is no evidence that retailers capture some of the demand expansion induced by the CAC promotions through higher retail prices and some very weak evidence that they may contribute to the effectiveness of the programs by lowering price to support industry promotions.

7. Evaluation of the HAB's Network Marketing Center Program

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

"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, 2003).*

All participants in the Hass avocado marketing chain have access to the HAB website (www.avohq.com) where they are able to share harvest and shipment planning information. The 2006-2007 Annual Report indicates that HAB's technology infrastructure supports over 2500 users and continues to grow (p. 3). This ongoing information exchange is intended to smooth shipments to major U.S. markets, prevent surplus and shortage situations, and promote stable f.o.b. 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 the HAB goal of 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 f.o.b. avocado prices over the most recent 10-year period (1995-96 through 2006-07). While there was not an evident trend over time, the weekly standard deviation for the most recent five years price averaged 0.2045, a decrease from the first five-year average standard deviation of prices of 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 (1995-96 through 2001-02) to an annual average of 4,303,944 pounds for the most recent five years (2002-03 through 2006-07). This indicates that, while California shipments have become more variable, coordination of imports with California shipments has smoothed total weekly avocado shipments and prices during the marketing year. The most recent five-year comparison of California with total weekly shipments (California plus imports) is shown in table 13. While growing imports had the potential to introduce additional

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
5-YR AVE.	4,303,944	2,309,312

quantity 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 f.o.b. and retail levels. A portion of the smoothing of quantity and prices as imports increased significantly can, and should be, attributed to the active HAB information programs.

Previous research for specialty agricultural commodities has demonstrated that decreased price variability can benefit both producers and consumers. Market conditions present in the U.S. avocado industry that can lead to this result are: (1) food retailers have market power in setting their retail prices, (2) the product is perishable, and (3) retail chains purchase the product directly from grower-shippers who 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 quicker and more fully to f.o.b. price increases than to f.o.b. price decreases.[31]

Li (2007) analyzed the price transmission process for avocados for increases and decreases in shipping point prices. She summarized 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 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 and retail price margins for avocados, thus, 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

[31]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 U.S.

consumers, and 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 and prices of avocados to U.S. markets benefit both producers and consumers.

7.2. Costs of HAB Information Programs

The annual costs of HAB information programs are listed by category in each HAB Annual report and are summarized in table 14. Annual expenditures for the information programs ranged from $340,179 to $1,090,228 over the five years, with an average annual cost of just

Table 14: Annual and Total Costs of HAB Information Programs by Cost Category, 2003 – 2007.

Cost Category	Year					Grand Total ($)
	2003	2004	2005	2006	2007	
Information ($)	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: HAB Annual Reports, 2003 – 2007.

under $750,000. Total five-year costs for the categories of information, analysis, and the Network Marketing Center were in a rather tight range of $530,514 to $536,936. Almost 57 percent of total costs for the first five years ($2,125,915) were in the interaction category.

7.3. Estimated Benefits from Information Programs

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 (f.o.b.) and the retail price of avocados. Thus, we assume that retail prices increased on average by 76 percent of the increase in shipping-point prices and decreased by 29 percent of the decrease in shipping-point prices. We use the aggregate estimated adjustment without attempting to account for the two to three weeks required for the total price adjustment, based upon Li's analysis. The changes in estimated gross marketing margins from week to week are based on total weekly shipments, the change in average weighted shipping-point price per pound for all Hass avocados and Li's estimated adjustment ratios.

Annual estimated gross changes in marketing margins, based on each marketing year's weekly total Hass avocado shipments and weighted weekly average Hass avocado shipping-point prices, are shown in table 15. 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 shipping point price changes vary from $2,889,059 in 2004 to just over $10 million in 2007. Note that the total changes in marketing margins are positively related to average weekly shipments and the standard deviation of weekly prices during the marketing year.

Table 15: Estimated Total Annual Changes in Gross Margins for Hass Avocados, Average Shipments, Standard Deviation of Price, and Average Price, 2003-2007

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

The standard deviation of weekly prices for each marketing year reported in table 15 measures actual price variability, but we also require an estimate of how different this variability would have been without the HAB information program. In other words, has price variability been reduced by the HAB information program and, if so, by how much? Our approach is to compare the variability of prices immediately before initiation of the information program with variability of prices after beginning 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 contributing to it.

As noted, the standard deviation of annual California Hass avocado prices decreased from an annual average of 0.2843 during the five-year period 1996 -2002 to an annual average of 0.2045 from 2003-2007. This decrease of 28 percent in price variability is used as the maximum reduction in price variability due to the HAB information program. The estimated total five-year increase in marketing margins as a consequence of price variability from table 15 is $31,661,000.

Considering that this figure represents the reduced value due to the presence of the information programs, the reduction of 28 percent 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.[32]

The division of the total benefit, as well as the assessment cost to fund the information program, between consumers and producers depends upon the value of consumers' price elasticity of demand, ε_D, relative to producers' price elasticity of supply, ε_S of 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 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 10 years. Although the estimate varies depending upon 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 upon the value assumed for ε_S. Assuming that the entire margin reduction can be attributed to the HAB's information program, the total net benefit is $12.3 million gross benefit minus $3.75 million program cost, or $8.55 million net benefit. Producers' share of this net benefit is then in the range of $0.94 - $2.82 million dollars, with the remainder of the net benefit going to U.S. avocado consumers.

---

[32] Let M_0 denote the increase in margin due to price variability in the absence of the HAB programs and $M_1 = 31{,}661{,}000$ equal the value in the presence of the programs. Then we have $(M_0 - M_1)/M_0 = 0.28$. Solving for M_1 and subtracting M_0 from it yields $12.3 million.

8. Data Collection Suggestions to Facilitate Future Evaluations

The U.S. avocado industry is fortunate to have a well-established industry-funded data source available. AMRIC, established by the CAC, collects and maintains a database that contains weekly, monthly, and annual observations by variety for avocado shipments by source and destination and for shipping point prices. The CAC also purchases retail level data for retail avocado prices and product movement in major U.S. markets.

The major data gap for evaluating HAB promotion programs is the lack of a systematic database of detailed information on promotional programs and expenditures. The CAC has published annual data on advertising/promotion expenditures in each of its annual reports. The HAB also includes promotion budgets and expenditures in its annual report together with a description of major initiatives and programs. The MHAIA and the CAIA each prepare an annual accounting statement that includes promotion expenditures but provide no description of programs. With four separate organizations advertising and promoting Hass avocados in the U.S. market there is a need for centralized data collection and reporting. The HAB is the logical entity to collect and maintain data on industry advertising/promotion programs, given its role in collecting and distributing funds to the CAC, MHAIA and CAIA and conducting its own promotion programs. Our ability to analyze promotion impacts at the disaggregate level was severely limited by lack of disaggregate expenditure data.

Our aggregate annual analysis used total promotion expenditures as the variable of interest to explain demand shifts. There are several limitations with this annual analysis that disaggregated weekly market-level data may help solve. First, annual analysis using total expenditure data assumes that all media are equally effective; that a dollar spent on radio has the same impact on demand as a dollar spent on television or print advertising. This is probably not true, and good, disaggregated data can be used to examine the responsiveness of retail sales to different media. However, even with the market level data utilized for the present study, it was necessary to assume that the “message” did not matter. Market level data can be used to test promotional messages, themes, or copy to help determine which is most effective. This requires careful attention to the data and information to be collected and may also require an experimental design using different messages in different markets.

We recommend that detailed advertising/promotion data be collected on a regular schedule by the HAB. The basic unit of observation should be geographic (individual retail market, region or national) with details on program target (consumers or subset such as homemakers 20 to 45 years of age, Hispanics, seniors, etc.; retailers; health professionals; institutions; etc.), timing of program (starting and ending dates), program expenditures carefully matched to the timing of the program, media used (radio, billboards, TV, newspapers, magazines, etc.) with the expenditure allocation if more than one medium is used, and finally, any measures of impact reported by media providers, third party agencies, or advertising agencies (media impressions, gross rating points, etc.). These data should be gathered on a weekly basis to coincide with the reporting interval for retail scanner data. The HAB can process the data to report weekly and monthly expenditures by market by media type, with descriptions of each program. It is very important to stress that failure of any of the participants in HAB-funded promotions to contribute to the data collection efforts described here has the potential to undermine the entire effort.

A second concern is that data collection efforts in retail markets by industry groups appear to be declining. As discussed in more detail in section 6, retail data were available for only seven of 16 promotion markets for 2008, whereas only two promotion markets were excluded in the data collection for the 2003-04 panel. We recognize that scanner data are expensive to purchase, but they do yield a wealth of information that is important to understanding promotion impacts and other facets of demand for avocados. These data acquisition costs should be shared industry-wide and supported under the auspices of the HAB.

9. Conclusions

The Hass Avocado Board faced significant organizational and economic challenges during its first five years of operations. It was able to meet these challenges by building on the long-standing programs of the California avocado industry, while planning and developing its own initiatives. This resulted in a smooth transition of promotion programs funded and conducted by the California industry to programs funded by HAB and conducted by CAC, CAIA, HAB and MHAIA, while successfully growing the U.S demand for avocados. A combination of effective promotion and information programs prevented a "feared collapse" of U.S. prices as imports soared.

9.1. Meeting the Import Challenge

U.S. avocado imports began to expand in the early 1990s, with growth becoming substantial as constraints on Mexican imports were eased and removed in a series of steps. Total Hass avocado imports to the U.S. market in 2002, the year before HAB began operating, were over 233 million pounds, U.S. production plus imports totaled over 633 million pounds and U.S. avocado consumption averaged 2.34 pounds per capita. Five years later in 2007, avocado imports totaled 760 million pounds, imports and domestic production totaled over 1.04 billion pounds and U.S. avocado consumption averaged 3.45 pounds per capita. The amazing fact in this growth story is that nominal California avocado prices averaged 89.50 cents per pound in 2002 and actually increased to 94.45 cents per pound in 2007, while per capita consumption increased by 47.4 percent. Without a significant increase in consumer demand, the story would have been much different. The annual f.o.b.-level demand for avocados in the U.S. is price inelastic, which means that relatively small percentage increases in supply can result in much larger percentage price decreases with other factors constant. The industry's programs to increase avocado demand successfully prevented a collapse in the price of avocados.

9.2. The Demand for Avocados

A number of factors are associated with the dramatic increase in the U.S. demand for avocados over the past decade. Previous studies of the demand for avocados have included variables for per capita avocado consumption, real prices per pound, advertising and promotion expenditures, real per capita consumer income, tastes and preferences (time trend), and Hispanic population (as a percent of total population). Efforts to identify substitutes or complements for avocados have met with limited success, perhaps due to the nature of available data. As noted, the Hispanic population variable, which may also include the effects of a large increase in Mexican restaurants and the growing popularity of Mexican and Southwest style cuisine, was an attempt to separate and identify factors typically lumped in the tastes and preferences category. Other factors, such as the increased seasonal availability of avocados due to imports, changing consumer lifestyles, and diet/health concerns, may also be associated with the increase in demand over time.

Initial specification of the demand equation for avocados included U.S. per capita consumption as the dependent variable, with independent variables for price, income, Hispanic population and promotion. After estimation by ordinary least squares methods, statistical tests indicated possible problems including structural change, multicollinearity, and simultaneous relationships. The demand equation was re-estimated sequentially using new trend and dummy variables to capture the effects of structural change. Estimated coefficients changed with each change in specification. The estimated coefficients for price remained relatively constant for each equation and the estimated price elasticity of demand ranged from -0.41 to -0.46 at average prices and quantities. The estimated coefficients for the promotion variable were the only other coefficients that were positive and statistically significant for each specification. The estimated coefficients for income and Hispanic population varied greatly by specification, were often statistically insignificant and were both dropped from the Model 1 two-stage least squares estimation. In short, the trend and dummy variables used to account for structural change effectively accounted for changes in demand measured by the variables for income and Hispanic population.

The impact of HAB promotion programs on the demand for avocados was the focus of this study. While the coefficient on promotion was always significant, its magnitude varied by specification, with the elasticity of promotion ranging from a high of 0.37 with the original equation to a low of 0.15 when the year and dummy variables were included in the demand equation. 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 a very conservative estimate.

9.3. Economic Evaluation of HAB Programs

HAB programs have two major objectives, to expand the U.S. demand for Hass avocados and to promote orderly marketing. Evaluation of HAB's degree of success required econometric estimation of the U.S. demand for avocados, simulation of promotion program costs and returns and examination of the variability of weekly avocado shipments and prices. Estimated demand equations indicate that HAB promotion programs had a statistically positive impact on the U.S. demand for avocados, with estimated promotion elasticities ranging from 0.148 to 0.372, depending upon model specification. The lower end of the range is very consistent with prior estimates for avocados and other commodities with successful promotion programs. Simulation of benefit/cost ratios using the highest and lowest estimated promotion response and supply elasticities ranging from 0.50 to 1.0 to 2.00 indicate that producer funded promotion programs not only expanded demand for avocados but provided a positive return on funds spent. The estimated B/C ratios range from 1.12 to 6.73, but, importantly, each exceeds 1.0, meaning that (a) the promotional programs supported by the HAB during its first five years yielded net benefits to producers and (b) could have been profitably expanded during the 2003-07 period of analysis. Given the range of promotional and supply elasticities used for the simulation, 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 programs 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 f.o.b. price increases than to price decreases, as occurs with avocados. Comparison of weekly avocado prices for five years before HAB with the first five years of HAB operations shows that price variability decreased an average of 28 percent. Estimated total producer and consumer benefits from HAB's information programs may have been as much as $12.3 million. Subtracting $3.75 million for program costs leaves net benefits of $8.55 million. Producers' share of this net benefit was estimated to be in the range of $0.94 - $2.82 million dollars, 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 the average retail sales in promotion markets compared with average retail sales in non-promotion markets. Previous results also suggest that radio is a more effective media than outdoor advertising but the difference in effects was not statistically significant. The opportunity to conduct evaluation based upon the available retail scanner data was limited by the industry's inability to systematically provide disaggregate promotion expenditure information. It was recommended that collection of such information be a priority to facilitate future reviews.

A potential problem with producer funded consumer promotion programs is that retailers 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, is not a problem limiting the impact of promotions. Instead, there is weak evidence that retailers may contribute to the effectiveness of the programs by lowering price to support industry promotions. Retail demand for avocados is significantly higher during particular holidays and events. Super Bowl Sunday had the highest sales, followed by Cinco de Mayo, Christmas/New Year, Independence Day, and Labor Day. Retail sales grew significantly over time for Cinco de Mayo week, with sales growth more than doubling in 2007 and 2008 compared to 2003 and 2004. Previous research found that retailers were using avocados as sale items during the high demand periods of Christmas/New Year, Super Bowl Sunday, and Cinco de Mayo, thereby further stimulating demand.

9.4. Bottom Line

The 13.2 percent average annual growth in U.S. per capita avocado consumption during the 10-year period 1998 through 2007 with essentially constant producer prices is unprecedented for a U.S. tree crop. Much of the credit must go to HAB promotion programs that have significantly increased the U.S. demand for avocados and have contributed to orderly marketing. Producers have received an attractive return on their assessments for HAB programs, with the most conservative estimate indicating a benefit/cost ratio of 1.12 for promotion expenditures. Information programs have helped reduce price variability and decrease retail margins with benefits flowing to producers and consumers.

References

Alston, J.M., J.A. Chalfant, J.E. Christian, E. Meng and N.E. Piggott (1997). *The California Table Grape Commission's Promotion Program: An Evaluation.* Giannini Foundation Monograph no. 43, November.

Alston, J.M., H.F. Carman, J.A. Chalfant, J.M. Crespi, R.J. Sexton, and R.J. Venner (1998). *The California Prune Board's Promotion Program: An Evaluation*. Giannini Foundation Research Report no. 344.

Alston, J.M., J.M. Crespi, H.M. Kaiser and R.J. Sexton (2005). "The Economics of Commodity Promotion Programs: Summary and Synthesis."in 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: Peter Lang Publishing, Inc., 387-415.

California Avocado Commission. *Annual Reports*. Irvine, California (2003-07). http://commission.avocado.org/

California Avocado Commission. *Business Plan*. Irvine, California (2004-05 through 2006-07). http://commission.avocado.org/

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

Carman, H.F. and R.K. Craft (1998). "An Economic Evaluation of California Avocado Industry Marketing Programs, 1961-1995." Berkeley: University of California Agricultural Experiment Station, Giannini Foundation Research Report No.345, July http://giannini.ucop.edu/ResearchReports/345-Avocado.pdf.

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

Carman, H. and R. Cook (1996). "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 (August): 227-234.

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

Chilean Avocado Importers Association. Annual Financial Statements (2003-07).

Cook, R. (2003). "The Avocado Market: A Growth Market in a Mature Food Industry." U. California, Davis, Dept. of Agricultural & Resource Economics. Avocado Brainstorming Session, October 2003, http://ucce.ucdavis.edu/files/datastore/234-65.ppt.

Crespi, J.M. and R.J. Sexton (2005). "Evaluating the Effectiveness of California Almond Promotion: How Much Did the Litigation Cost Producers?" in 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: Peter Lang Publishing, Inc, pp. 387-415.

Hass Avocado Board. Annual Reports. Irvine, California (2003 – 2007).

Hass Avocado Board. Domestic Marketing Plan. Irvine, California (2004-05 through 2006-07).

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

Kinnucan, H.W. and Y. Zheng (2005). "National Benefit-Cost Estimates for the Dairy, Beef, Pork and Cotton Promotion Programs." in 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: Peter Lang Publishing, Inc., 255-284.

Li, L. (2007). "Retailer Pricing Behavior for a Fresh Produce Commodity: The Case of Avocados." Ph.D. Dissertation, University of California, Davis, 528 pp.

Mexican Hass Avocados Importers Association (MHAIA), Hass Avocado Marketing Campaign Plans, prepared by the Preston/Tully Group Inc. (2003 – 2007).

Mexican Hass Avocados Importers Association (MHAIA), Letter of Agreement and Budget Allocation between MHAIA and the Preston/Tully Group Inc. (2003 – 2007).

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

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

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

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

U.S. Department of Agriculture (2004). "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.

Wolfe, K. and C. Ferland (2003). "Estimated Fresh Salsa Market Potential for Georgia and Bordering States". University of Georgia, Dept. of Agricultural & Applied Economics, FR-03-01. http://www.agecon.uga.edu/~caed/SalsaIndustry.pdf.

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