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Measuring the Impact of Advertising and Promotion: Single- or Multi-Equation Systems? A Case Study of the Washington Apple Industry

Hilde van Voorthuizen, R.Thomas Schotzko, and Ron C. Mittelhammer

This paper reports the results of a case study analyzing the impacts of promotion and advertising conducted by the Washington Apple Commission (WAC) using both single- and multi-equation systems. The analyses are compared in terms of the comparability and coherency of results and in terms of the types of information that can be generated by the multi-equation model but not by the single-equation model.

Due to the availability of detailed data from the WAC, the multi-equation system incorporates measures of actual lines of print media within an explicit model of print media as well as a measure of the multiplier effect associated with WAC promotion expenditures relative to the overall (retail-matched) level of print media. This information cannot be effectively included in a single-equation analysis. The multi-equation system also includes supply-response and price linkages between F.O.B. and retail levels. Monthly data are used for all systems.

The results of this study suggest that in terms of predicting the quantity effects of promotion expenditures, if one conditions on F.O.B. price levels the effects of non-trade activities from the single equation are not statistically significant and seasonality is not a major factor in determining monthly demand. Conversely, within the multi-equation approach, results of this study suggests that non-trade activities *did have* a measurable impact on the demand for Washington apples and that seasonality is a major factor in determining monthly demand.

In terms of predicting the price effects of promotion expenditures, if one conditions on supply elasticities, the approaches provide similar predictions of price impacts. However, the simultaneous supply feedback is significant in the apple industry case, so, by taking the interaction of supply and demand into account, the more complex multiple-equation approach predicts notable supply response-induced mitigation in price increases originally induced by promotion efforts relative to when impacts of promotions are measured under scenarios of a fixed supply function. Actual cost estimates by type of analysis are also provided for each approach. The estimates are based on actual costs incurred in conducting the analyses. The results of the case study provide a basis for assessing the necessity, as well as the benefits and costs, of conducting a detailed and complex multi-equation promotion evaluation relative to a simpler and more focused single-equation analysis of promotion effectiveness.

Economic evaluations of the effectiveness of promotion programs have become a necessary fact of life for commodity commissions in the U.S. and the produce sector is no exception. The Washington Apple Commission began funding evaluations of promotional impacts using econometric techniques in the early 1990s (Ward 1993). More recently, econometric evaluations of promotional impact have been done for commissions promoting table grapes (Alston et al. 1997), prunes (Alston et al. 1998), avocados (Carman and Craft 1998), and winter pears (Erikson et al. 1997; Erikson 1999), for example.

These evaluations can be costly, and to some extent divert already scarce grower resources away from their intended use in promoting the commodities under the purview of the commission. Using simple single-equation predictive models can substantially reduce the financial cost of such evaluations. Moreover, the reduced scope and complexity of single-equation models might enable some commissions to perform more regular and timely program evaluations in-house. However, simple single-equation analyses can also entail a loss of estimation and predictive accuracy as well as a loss in the breadth of information generated in comparison to broader and more complex multi-equation methods of analyses.

This paper reports the results of a case study analyzing the impacts of promotion and advertising conducted by the Washington Apple Commission (WAC) using both single- and multi-equation

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systems. Within the multi-equation systems, two approaches are considered: a case where supply response is represented *a priori* through elasticities, and a case where simultaneous supply feedback interacting with demand is taken into account. The analyses are compared in terms of the comparability and coherency of results and in terms of the types of information that can be generated by the multi-equation model but not by the single-equation model.

Because of the availability of detailed data from the WAC, the multi-equation system incorporates measures of actual lines of print media within an explicit model of print-media output as well as a measure of the multiplier effect associated with WAC promotion expenditures relative to the overall (retail-matched) level of print media. This multiplier effect cannot be effectively measured in a single-equation analysis. The multi-equation system also includes endogenous supply-response and price linkages between F.O.B. and retail levels. Monthly data are used for both the multi-equation systems and the single-equation model.

Actual cost estimates by type of analysis are also provided for each approach. The estimates are based on actual costs incurred in conducting the analyses. The results of the case study provide a basis for assessing the necessity, as well as the benefits and costs, of conducting a detailed and complex multi-equation promotion evaluation relative to a simpler and more focused single-equation analysis of promotion effectiveness.

Methodology and Model Overview

In this section we provide an overview of the single- and multiple-equation models used to simulate advertising effects on the Washington State Apple Industry. The models represent the results of *a priori* postulation, data limitations, and empirical performance of various specifications. Additional details and motivation for the full system can be found in Van Voorthuizen (2001).

Single Equation: Demand Equation Formulation

The effects of promotion and advertising on demand are conceptually formulated and econometrically estimated as

$$(1) \quad \begin{aligned} QDW_{tr}/POP_{tr} = & f(PFOB_t, RINC_{tr}/POP_{tr}, PP_t, \\ & \sum_{i=0}^n \sum_j ADV_{t-i,j,r}/POP_{t-i,r}, QDW_{t-1,r}/POP_{t-1,r}, \\ & QDW_{t-12,r}/POP_{t-12,r}, t, t^2, t^3, \sum_{i=0}^n Logos_{t-i,r}, \\ & \sum_{i=0}^n Color_{t-i,r}, \sum_{r=1}^4 Region_r, other, u_{tr}) \end{aligned}$$

where

QDW_{tr} = total quantity demanded of apples in month t , region r ;

r = regions of the U.S. (Midwest, Southwest, Northeast, Southeast, Northwest—see Figure 1).

Pop_{tr} = population in month t , region r (expressed in millions);

$PFOB_t$ = the F.O.B. price per pound of Washington apples that prevailed during month t

$RINC_{tr}$ = the real disposable personal income per million people in month t , region r ;

PP_t = substitutes and/or complements measured in prices per pound in month t , specifically bananas, and pears;

$ADV_{t-i,j,r}$ = a vector of advertising expenditures per million people in period $t-i$, for $i = 0, 1, \dots, n$; in expenditure category $j =$ mass media, trade merchandising (display, give-away products, trade services, and other in-store promotional activities), region r .

$QDW_{t-1,r}$ = total quantity demanded of apples in month t , region r , lagged one period;

$QDW_{t-12,r}$ = total quantity demanded of apples in month t , region r , lagged 12 periods;

$Logos_{tr}$ = the weighted number of ad lines of ads associated with a logo in month t , region r ;

$Color_{tr}$ = the weighted number of lines in a colored format in month t , region r ;

t, t^2, t^3 = a cubic polynomial time trend, repeating $t = 1, \dots, 12$, to capture seasonal consumption patterns;

Other = Other variables having an impact on demand such as quantities of apples demanded from New York, Michigan, and California, a time trend (YT) capturing long-term secular changes in demand, and others;

u_{tr} = the error term to capture any remain-

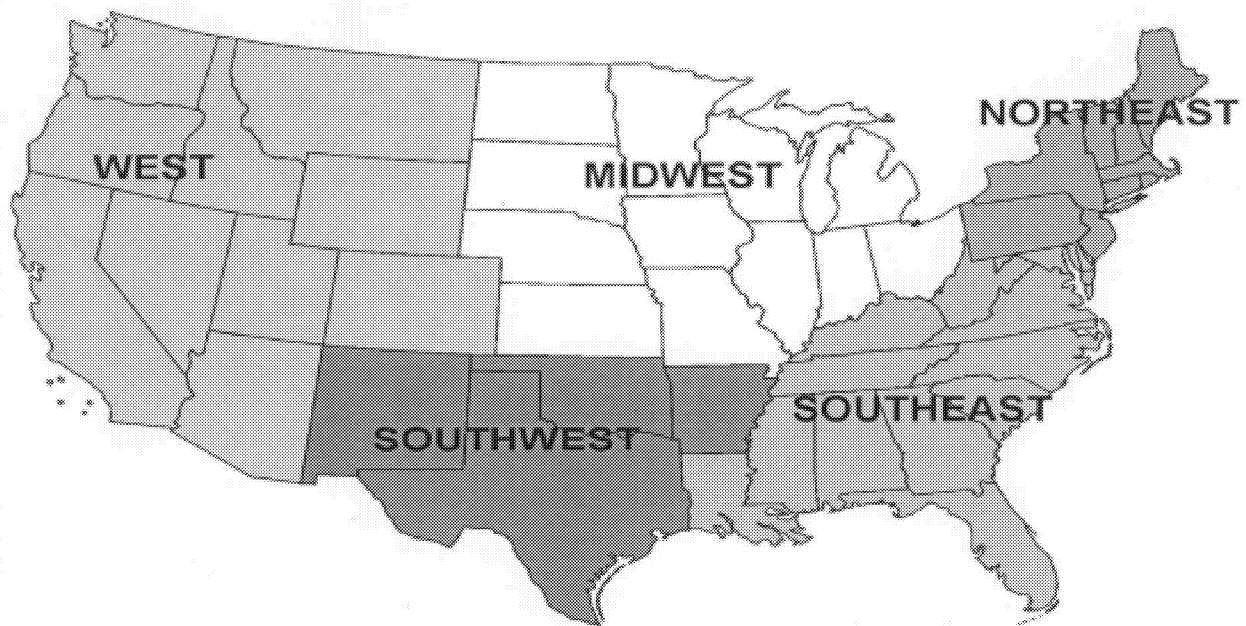


Figure 1. U.S. Map Divided By Regions To Evaluate The Washington Apple Industry's Promotion Programs.

ing effect not included in the model.

All prices and advertising expenditures are introduced into the estimation process in real terms. The multi-equation analysis is conducted on a regional basis. The regions are based on territorial sales and population distributions (Figure 1).

We emphasize that the single-equation demand analysis in this study is such that seasonal effects are captured via a polynomial time trend based on observed shipment patterns throughout the marketing season; regional differences are represented through indicator variables; and advertising carryover effects are evaluated by the inclusion of two variables, $QDW_{t-1,r}$ and $QDW_{t-12,r}$, which proxy habit-persistence effects (Erickson). The procedure used to capture the advertising and promotion carryover effects is different from the procedures suggested by Nerlove and Waugh (1961), Carman and Craft (1998) and Chung and Kaiser (2000).

In our final model the habit-persistence variables ($QDW_{t-1,r}$ and $QDW_{t-12,r}$) prove to be statistically significant. Assuming a linear functional form in the variables, differentiation leads to the 12-month cumulative advertising carryover effect on demand over time, holding all other variables con-

stant, as

$$(2) \quad \begin{aligned} (\partial QD/\partial ADV)_{12\text{months.cum}} &= \partial QD/\partial ADV_{t,j} + \\ &\sum_{i=1}^{11} (\partial QD/\partial QD_{t-i} \times \partial QD_{t-i}/\partial ADV_{t-i,j}) \\ &= \beta_{ADV_j} + \sum_{i=1}^{11} \beta_{QD_{t-i}}^* \beta_{ADV_j} \end{aligned}$$

In equation (2), QD represents QDW/POP for simplicity. Also, Adv_j is defined as Adv/POP (the advertising expenditure per million people incurred in category j). The β s are the corresponding estimated coefficients, $i = 1$ (past month), $2, \dots, 11^{\text{th}}$ past month in which advertising expenditures occurred, but still positively impacting the current month's consumption. Similarly, the marginal cumulative advertising effect on demand in the 13th month, holding other variables in the entire system constant, is given by

$$(3) \quad \begin{aligned} (\partial QD/\partial ADV)_{13\text{months.cum}} &= \partial QD/\partial ADV_{t,j} + \\ &\sum_{i=1}^{12} (\partial QD/\partial QD_{t-i} \times \partial QD_{t-i}/\partial ADV_{t-i,j}) + (\partial QD/\partial QD_{t-1} \times \\ &\partial QD_{t-1}/\partial QD_{t-13} \times \partial QD_{t-13}/\partial ADV_{t-13,j} + \\ &\partial QD/\partial QD_{t-12,1\text{st-year}} \partial QD_{t-12,1\text{st-year}}/\partial QD_{t-13} \times \\ &\partial QD_{t-13}/\partial ADV_{t-13,j}). \end{aligned}$$

The advertising carryover effects of the thirteenth-month can be added to the cumulated carryover effects of the first marketing year. Cumulated advertising carryover effects for subsequent periods are obtained by continuing to accumulate the carryover effect through time and adding the results to equation 3.

Multi-Equation Systems

The multi-equation system includes a set of retail-demand equations and a set of retail-F.O.B. price-transmission equations, both of which are differentiated by regions of the United States. In addition, two approaches are considered in the multi-equation system: 1) the case where supply response can be anticipated *a priori* through supply response elasticities, and 2) the case where simultaneous supply feedback interacting with demand is taken into account. Methods and data are detailed in Van Voorthuizen (2001). Each model component is described in subsequent sections of this paper.

The Demand Equation

The set of retail-demand functions in which advertising and promotion-program performance is evaluated is as

$$(4) \quad \begin{aligned} QDW_{tr}/POP_{tr} = & f(P_{retailtr} \times (1 - adexp_{tr}), Adprice_{tr} \\ & \times adexp_{tr}, RINC_{tr}/POP_{tr}, PP_{tr}, \sum_{i=0}^n Adlines_{t-i,r}, \\ & \sum_{i=0}^n ADV_{t-i,j,r}/POP_{t-i,r}, QDW_{t-1,r}/POP_{t-1,r}, \\ & QDW_{t-12,r}/POP_{t-12,r}, t, t^2, t^3, \sum_{i=0}^n Logos_{t-i,r}, \\ & \sum_{i=0}^n Color_{t-i,r}, \sum_{r=1}^4 Region_r, other, u_{tr}) \end{aligned}$$

Equation 4 is similar to the single-demand equation except for three important differences: the demand equation is estimated at the retail level instead of at the F.O.B. level, regular prices and promotional-price effects are taken into account explicitly and regular retail price (Pretail) and promotional price (adprice) are adjusted by a variable that accounts for the amount of time each price is in effect in a regional market (Adexp), and physical measures of advertisement are used instead of advertising expenditures (ad lines, ads containing a logo [logos] and colored ads [color]). The promotion measures are constructed as market-share-

weighted averages of major market-area levels, which are further expressed on a per-capita basis, accounting for populations in the major markets. Complete details of variable definitions are provided in Van Voorthuizen (2001).

An Adline linkage equation was formulated using the number of ad lines placed in a given region in a given time period, and used in the evaluation of the effects of print media on demand and industry returns:

$$(5) \quad \begin{aligned} Adlines_{tr} = & \beta_0 + \beta_1 Adbuys_{tr} + \beta_2 Adlines_{tr-1} \\ & + \beta_3 Adlines_{tr-12} + \beta_4 Pretail_{tr-1} + \sum_{i=1}^{11} \beta_{5i} Season_i \end{aligned}$$

where

$Adlines_{tr}$ = the weighted number of ad lines appearing in month t , region r ;

$Adbuys_{tr}$ = the total amount of ad-buy expenditures authorized by WAC in month t , region r , to finance print-media advertisement, expressed in real terms;

$Adlines_{tr-1}$ = the weighted number of ad lines lagged one period to account for monthly advertising persistence;

$Adlines_{tr-12}$ = the weighted number of ad lines lagged twelve periods to account for year-to-year advertising persistence;

$Pretail_{tr-1}$ = the regular retail price lagged one period and expressed in real terms in month t , region r , to account for retailer print-media activity incentive on a monthly basis (in the absence of information regarding retailer print-media expenditures);

$Season_i$ = January, February, ..., December indicator variables to account for seasonal effects.

This linkage equation is needed because retailers and the industry conjunctively support print-media advertisements, but the amount of dollars allocated by retailers to purchase print media is unknown. The above model is formulated and empirically estimated according to our best economic intuition of what motivates the WAC and retailers to place more or fewer ads on a month-to-month basis, subject to the limited data available. The model presented in Equation 5 is also differentiated on a regional basis (Figure 1). However, in this case, separate equations were estimated for each

region rather than using indicator variables to differentiate regional levels. Equilibrium quantities and prices were better approximated by separate regional equations.

A Set of Retail-F.O.B Price-Transmission Equations

The second component of the evaluation process is the modeling of the relationship between retail and F.O.B. prices. Thus, a set of retail-F.O.B. price-transmission equations are theoretically formulated and econometrically estimated. The price-transmission model used in the evaluation process is composed of wages and transportation costs as prescribed by economic theory. It also includes a variable, PC sales (accumulated PC sales over time and depreciated over three year period), that we use to test the hypothesis that advances in information technology in the retail sector have had a negative effect on the price spread. The price-transmission model also includes exchange-rate variables accounting for the Asian and Mexican financial crises under the hypothesis that these crises had disruptive effects on the marketing channel. Hence, the price-transmission equation is expressed as

$$\begin{aligned}
 \text{Pretail}_{ir} = & \alpha + \sum_{r=1}^5 b_{1r}(RI_r \times \text{Pretail}_{t-1,r}) + \\
 & \sum_{r=1}^5 b_{21r}(RI_r \times PFI_t) + \sum_{r=1}^5 b_{22r}(RI_r \times PFF_t) + \\
 (6) \quad & \sum_{r=1}^5 b_{3r}(RI_r \times TC_t) + \sum_{r=1}^5 b_{4r}(RI_r \times Wage_t) + \\
 & \sum_{r=1}^5 b_{5r}(RI_r \times PCsales_t) + b_6 \times MC_t + b_7 \times AC_t + \\
 & \sum_{i=1}^{12} b_8 \text{Seasonality}_i
 \end{aligned}$$

where

- Pretail_{ir} = the nominal retail price per pound of Washington apples in region r , month t , expressed in nominal terms;
- RI_r = regional indicator variables, $j = 1, 2, \dots, 5$, where 1 is the Midwest, 2 the Northeast, 3 the Southeast, 4 the Southwest, and 5 the West;
- $\text{Pretail}_{t-1,r}$ = the nominal lagged retail price per pound of Washington apples in region r ;
- PFI_t = a vector of cumulative increases in the nominal F.O.B. price per pound of

fresh apples in month t ;

PFF_t = a vector of cumulative decreases in the nominal F.O.B. price per pound of fresh apples in month t ;

TC_t = a U.S. transportation-cost index in month t ;

$Wage_t$ = a U.S. retail-wage index in month t ;

MC_t = a variable to capture the Mexican crisis effects, proxied by the exchange rate in month t ;

AC_t = a variable to capture the Asian crisis effects and is proxied by a weighted exchange rate in month t ;

$PCsales_t$ = the total nominal value of cumulated and depreciated personal-computer sales in the U.S. in month t ;

Seasonality = indicator variables for each month of a year, where 1 is January, ..., and 12 is December.

In the above model, price stickiness is tested through the lag of the dependent variable, and symmetry in retail-F.O.B. price response is relaxed through the method suggested by Kinnucan and Forker (1987).

Industry Supply Behavior: The Case Where Supply Response Can Be A Priori Anticipated Through Elasticities

Under this scenario, equation 7 ahead is assumed to represent the industry supply curve and the value of the parameter β_1 is recovered by using an estimated elasticity of supply.

$$(7) \quad QSW_t = \beta_1 PFR.$$

Industry returns are evaluated under the scenario that supply is fixed in the short run.

Industry Supply Behavior: The Case Incorporating Simultaneous Supply Feedback Interacting with Demand

During the period of study (September 1990 through August 2000) the Washington Apple industry was exposed to factors that exerted a direct impact on supply response. Among those factors are seasonal effects, industry response to the Mexican and Asian crises, and inventory levels, to mention a few. Each factor impacts month-to-month decisions in terms

of product allocation in domestic markets. The supply of Washington apples is empirically modeled as

$$(8) \quad QSW_t = (PFR_t, PFR_{t-1}, POM_t, POM_{t-1}, w_t, \gamma_0 + \gamma_2 T_t + \gamma_3 T_t^2 + \gamma_4 T_t^3, MC_t, AC_t, LCRP_t, IMI_t, EX_{t-1}, \text{Time-trend}_t, u_t)$$

where

- QSW_t = the total quantity of fresh apples supplied to the domestic market in month t ;
- PFR_t = expected F.O.B. price per pound of fresh apples in month t ;
- POM_t = the prices from alternative markets such as the export market and the processing sector, in month t , expressed in dollars per pound;
- w_t = a matrix of input costs for producing and warehousing fresh apples in month t , expressed in nominal terms;
- $T, T^2, \text{ and } T^3$ = polynomial time trend meant to capture seasonal patterns in supply throughout a marketing year. $T = 1$ for January, ..., 12 for December; γ_i are coefficients to estimate;
- MC_t = Mexican crisis affecting aggregate supply to domestic markets, proxied by the Mexican exchange rate in month t ;
- AC_t = Asian crisis affecting aggregate supply to domestic markets, proxied by exchange rates in month t ;
- $LCRP_t$ = an indicator variable for large crop years (1994, 1996, and 1998).
- IMI_t = the beginning inventory in month t ;
- EX_{t-1} = total exports lagged one month;
- Time trend = 1 from September 1990 through August 2000, 0 otherwise, to proxy for secular changes in supply over time;
- u_t = the error term that captures effects of variables not included in the model.

Results

The Single-Demand Equation

Except for the polynomial time trend used to capture seasonal patterns in consumption, the final

demand model is linear in all of the variables and in their respective parameter estimates. The model was estimated using 2SLS. The endogenous variables in the final model are total quantity shipped of the five varieties (Red Delicious, Golden Delicious, Granny Smith, Gala, and Fuji), retail price, the F.O.B. price, the current month's trade-category expenses, and the current month's ad lines. A number of alternative specifications were evaluated with this specific model providing the best overall results.

The R^2 for the second stage is reported in Table 1. Descriptive statistics and coefficient estimates from the second stage of 2SLS are also reported in Table 1. Significant variables included the F.O.B. price, the price effects of bananas, the simple average price of domestic and imported pears, and imported-apple price in the months of March, April, and May when greater imports of apples occurs. According to the single-equation model, quantities of apples supplied by the states of Michigan, New York, and California do not have an impact on domestic demand for Washington apples. The income variables were nonsignificant and had the incorrect sign.

Regarding the promotional activities coordinated by WAC, only trade activities including ad buys (the level of expenditures in print media financed by WAC) were positive and statistically significant. TV and radio appear not to have a measurable impact on domestic demand. Other promotional expenditures such as food service, billboards, and outdoor activities did not have a measurable impact on the demand for Washington apples.

Regional demand for Washington apples differs except in the Southwest—the base region—and the Southeast. It appears that demand for Washington apples is considerably higher in the West than in the other regions. In the single-demand equation, seasonal effects do not have an impact on quantity demanded of Washington apples in the U.S.

Multi-Equation System

The Demand Model

The demand model is estimated using 2SLS. The endogenous variables in the final model are total quantity shipped of the five varieties (Red Delicious, Golden Delicious, Granny Smith, Gala, and

Table 1. Statistical Results for the Demand Equation, Single-Equation System.

Variable name	Mean Value	Standard Deviation	Parameter Estimate	T for H_0 : Parameter = 0
F.O.B. price in real terms	0.21	0.04	-704,247.00	-4.63
$(QDW_{t-1}/POP_{t-1})^a$	729,356.00	245,964.00	0.18	5.50
$(QDW_{t-12}/POP_{t-1})^a$	729,628.00	246,169.00	0.44	12.81
Mid-West RINC ^a			4.75	2.26
North-East RINC ^a			(Scorea)	
South-East RINC ^a				
South-West RINC ^a				
West RINC ^a				
CIF for bananas (real terms)	0.08	0.01	2,619,091.00	3.91
Simple average of Price of pears (real terms)+import price of pears (real terms)	0.25	0.16	846,686.39	2.01
Import price of Apples (real terms) in March, April, and May	0.04	0.08	184,657.20	2.64
QNY (in lbs) ^a + QMI (in lbs) ^a	798,161	528,729	-0.005	-0.48
Ad buys in real terms lagged one period	195.70	121.00	76.69	2.17
Non-trade expenditures in real terms lagged one period ^a	2,264.70	2,994.90	0.84	0.55
Trade expenditures (real terms) ^a	47.678	56.51	244.49	2.45
Other promotional expenses (real terms) ^{1 a}	21.48	128.10	127.29	2.99
Midwest indicator variable			-32,299.30	-2.44
Northeast indicator variable			-53,970.80	-3.87
Southeast indicator variable			-9,054.30	-0.67
West indicator variable			145,651.10	7.46
Indicator variable for the 98 crop year			67,428.95	4.97
YT			-570.70	-1.47
T			-17,793.50	-0.75
T ²			-212.59	-0.05
T ³			119.31	0.50
Indicator variable for December of each marketing year			103,867.2	3.46
Indicator variable for March of each marketing year			80,710.49	14,799.20
QDW/POP (dependent variable)	727,389	246,163		
POP (Regional population in millions)	52.61	12.67		
Regional CPI for food items	1.53	0.12		
R ² =0.98 N = 575	Durbin h test = 1.75			

¹ Refers to different trade-related efforts realized together, but segregation was not possible while organizing the data for analysis.

^a Per million people.

Table 2. Statistical Results for the Demand Equation, Multi-Equation System.

Variable name	Mean Value	Standard Deviation	Parameter Estimate	T for H ₀ : Parameter = 0
$(P_{\text{retailtr}} * (1 - \text{adexp}_{\text{tr}}) + \text{Adprice}_{\text{tr}} * \text{adexp}_{\text{tr}})$ in real terms	0.564	0.069	-229,262	-2.44
$(QDW_{t-1} / POP_{t-1})^a$	726,356.00	245,964.00	0.12	3.83
$(QDW_{t-12} / POP_{t-1})^a$	729,628.00	246,169.00	0.39	11.99
Mid-West RINC ^a	14,484	714.85	2.19	2.79
North-East RINC ^a	17,684	1,117.90	3.45	2.79
South-East RINC ^a	14,377	711.98	2.02	2.79
South-West RINC ^a	14,411	963.49	2.91	2.79
West RINC ^a	16,203	685.77	1.90	2.79
CIF for bananas (real terms)	0.08	0.01	1,054,830.00	1.70
Simple average of Price of pears (real terms)+import price of pears (real terms)	0.26	0.16	78,099.38	2.06
Import price of Apples (real terms) in March, April, and May	0.05	0.08	129,408.70	2.04
QNY (in lbs) ^a + QMI (in lbs) ^a	798,161.00	528,729.00	-0.03	-3.04
Ad lines	2,927.30	2,219.40	16.53	4.77
Logos/Ad lines	0.76	0.18	66,249.25	3.30
Color/Ad lines	0.80	0.16	98,174.66	6.94
Non-trade expenditures in real terms lagged one period ^a	48.14	56.52	2.81	1.960
Trade expenditures (real terms) ^a	2,264.70	2,994.90	223.85	2.39
Other promotional expenses (real terms) ^{1 a}	21.49	128.10	76.29	1.90
Midwest indicator variable			-95,320.80	-6.16
Northeast indicator variable			-91,161.60	-5.11
Southeast indicator variable			-79,184.40	-4.87
West indicator variable			90,714.02	4.85
Indicator variable for the 98 crop year			74,517.12	5.69
YT			-2,276.97	-5.89
T		38,196.44	1.85	
T ²			-8,692.57	-2.23
T ³			474.36	2.29
Indicator variable for December of each marketing year			108,594.90	3.90
Indicator variable for March of each marketing year			67,054.77	4.99
QDW/POP (dependent variable)	727,389.00	246,163.00		
POP (Regional population in millions)	52.61	12.67		
Regional CPI for food items	1.53	0.12		
R ² =0.99 N = 575	Durbin h test = 2.98			

¹ Refers to different trade-related efforts realized together, but segregation was not possible while organizing the data for analysis.^a Per million people

Fuji), retail price, promotional price of Washington apples, the current month's trade-category expenses, and the current month's ad lines.

The R^2 for the second stage is reported in Table 2. The Durbin h test reported in Table 2 indicated no autocorrelation. Descriptive statistics and coefficient estimates from the second stage of 2SLS are also reported in Table 2.

Price-Promotion Effects

The coefficients for the retail-price and the promotional-price variables were found through a Wald test to be not significantly different from one another. Therefore, a weighted measure of the form $(P_{retailtr}^{*}(1-adexp_{tr}) + Adprice_{tr}^{*}adexp_{tr})$ was formulated as a substitute for the individual variables in the final demand equation. The weighted price measure (retail and promotional-discount prices) is expressed as weighted price per pound in real terms. The mean value of the new weighted price per pound is \$0.564 and the own price elasticity is -0.177 when evaluated at this mean level.

Effects of Non-Price Promotional Efforts

As suggested by a principal-component analysis and a Wald test, demos, displays, and giveaway products are grouped into one category (the trade-category expenses). Similarly, radio and TV are grouped into a single category (the non-trade-category expenses). Both categories had significant and positive impacts on the demand for Washington apples.

Other promotional expenditures such as food service, billboards, and outdoor activities did not have a measurable impact on the demand for Washington apples. Regarding characteristics of the ad-lines print media, the proportion of logos and the proportion of color ads have positive and significant additive effects on the demand for Washington Apples.

In terms of the ad-line print-media equations as specified in equation 5, each regional equation is estimated using OLS. This method is used because all variables used to describe the behavior of ad lines, including ad buys, are considered predetermined. A Hausman test for endogeneity was non-significant, supporting the use of OLS as an appropriate estimation technique. The ad-lines print-media R^2 ranges between 0.77 to 0.82, suggesting that the exogenous variables in each equation ex-

plain most of the variation in ad lines. Autocorrelation tests were insignificant for all equations. All variables in each of the equations are expressed in linear form.

The ad-lines observations contained unexplained outliers. Indicator variables for the months in which these outliers occurred were introduced into the modeling process. The anomalous outliers are not consistent across regions, so the indicator variables for the outliers vary across equations (regions). Results for each individual equation are shown in Table 3 through Table 7.

According to the results in Tables 3 through 7, distinct inferences can be made with respect to the manner in which ad lines appear in a region and their relationship with WAC ad-buys/print-media expenditures. These inferences are

- 1) The coefficients of ad buys and the level of ad-buy expenditures for the Midwest and Southeast region are larger relative to the other regions. The ad-lines/ad-buys elasticity evaluated at the mean level for both regions are 0.24 and 0.37, respectively.
- 2) The ad-line/ad-buy elasticity evaluated at the mean level for the Northeast and West region are 0.14 and 0.21, respectively.
- 3) The Southwest region has the lowest coefficient and lowest level of ad-buy expenditures among all regions. The elasticity evaluated at the mean level is 0.10 percent.
- 4) These elasticities reflect the level of funding the commission contributes to overall print media.
- 5) The number of ad lines used in the current period depends on the number of ad lines that were used in the past month for all regions. Ad lines lagged 12 periods are not a significant factor in explaining current-period ad lines.
- 6) Fewer ad lines are run in late spring and in early summer in each marketing year in all regions.
- 7) More ad lines were used in marketing years 1997 and 1998 in all regions relative to other marketing years.

Persistent Preferences and Promotional Effects

Habit persistence was found to affect demand just as in the case of the single-demand equation (Table 2). The previous month's consumption of apples is positively related to the current month's consumption. Apple consumption in the corre-

Table 3. Statistical Results for the Ad-Lines Equation (Midwest Region).

Variable name	Mean Value	Standard Deviation	Parameter Estimate	T for H_0 : Parameter = 0
Intercept			7,025.27	4.19
Ad-buy expenditures	12,273.80	6,406.00	0.06	2.63
Lines lagged one period	3,313.70	2,444.10	0.43	5.96
Retail price lagged one period	0.64	0.05	-8,331.64	-3.38
Indicator variables for month				
April			-846.04	-2.08
May			-1,641.23	-4.20
June			-2,126.07	-5.12
July			-1,120.60	-2.60
August			-1,025.12	-2.41
Indicator variables for marketing year				
1992			-1,766.68	-4.12
1993			-539.29	-1.33*
1994			-569.38	-1.33*
1995			1429.62	3.27
1997			834.53	1.92
1998			3,640.04	3.03
1999			2,688.06	2.24
October of 1997 marketing year				
March of 1998 marketing year				
Ad lines (dependent variable)	3,310.600	2,445.8		
CPI for food items	1.52	0.12		
$R^2 = 0.81$ $N = 113$				
	Durbin h test = 0.71			

* Non-significant at the 0.10 level.

The base period for the monthly and marketing-year indicator variables is those months (years) not appearing in these results.

sponding month of the previous year is also positively related to the consumption of apples in the current month. The significance of the lagged quantity variables (quantity lagged one period and quantity lagged twelve months) means that higher returns are accrued in the long run than in the short run.

Other Factors Affecting Demand

The regional income variables (RINC) in Table 2 derived from principal-component scores were positive and significant across regions, indicating that apples are normal goods and as income rises a greater quantity of apples is demanded, as opposed to the single-demand equation where the effect of income was insignificant and negative.

Substitutes in the demand model (Table 2) are imported apples, Michigan and New York apples, imported and domestic pears, and imported bananas. The Wald test indicated that the effects of Michigan and New York shipments are insignificantly different but statistically significant, contradicting the single-equation model results.

The imported-apple price effects are measured with an indicator that interacted with imported price for March, April, and May, those months when imports are most pronounced and when domestic shipments of Washington apples are higher relative to the rest of the season. Import price interacting with the months of June and July were also tested, but the joint effect with the months of March, April, and May was insignificant. The coefficient sign for

Table 4. Statistical Results For The Ad-Lines Equation (Northeast Region).

Variable name	Mean Value	Standard Deviation	Parameter Estimate	T for H_0 : Parameter = 0
Intercept			411.67	2.30
Ad-buys expenditures	10,461.9	7,468.4	0.02	2.30
Lines lagged one period	1,646.50	1,240.60	0.46	7.45
Indicator variables for month				
January			467.04	2.30
May			-397.31	-2.04
June			-644.91	-3.21
July			-413.38	-1.99
August			-393.01	-1.87
Indicator variables for marketing year				
1996			279.69	1.49*
1997			1,022.95	4.65
1998			1,045.94	4.32
1999			344.33	1.61*
January and February 1994			2,323.28	5.23
October 1998			2,473.73	4.15
October 1999			1,606.11	2.70
Ad lines (dependent variable)	1,643.20	1,243.70		
CPI for food items	1.57	0.09		
$R^2 = 0.82$ $N = 115$	Durbin h test = 0.63			

* Non-significant at the 0.10 level.

The base period for the monthly and marketing-year indicator variables is those months (years) not appearing in these results.

the imported-apple price interacting with these months was positive, as hypothesized. The magnitude of the estimate was 129,408.70, indicating that as this variable increases (decreases) by a dollar unit, demand for apples would increase (decrease) by approximately 129,408.70 pounds. The imported- and domestic-pear coefficient also has the hypothesized sign and is statistically significant.

Contrary to the single-equation demand model, seasonality of demand was also evident across months within a marketing year in the multi-demand-equation system approach (Table 2). By adding the seasonal time trend ($t+t^2+t^3$) and evaluating it at each month of the year (1 for January, 2 for February, ..., 12 for December), differences in demand across seasons is more apparent. Differences in consumption patterns throughout the U.S. were also detected in the final results. In addition to the polynomial time trend, the overall time trend (YT)

included in the model to capture secular changes in demand over time was also found to have a negative impact on the current-month demand of Washington apples. The negative coefficient of the time-trend variable potentially reflects the emergence of more diverse eating habits and the growing demand for specialty and ethnic fruits over time.

The F.O.B.-Price-Transmission Model Results

Results for the price-transmission equation is shown in Table 8. The R^2 for this part of the overall model was 0.715, which indicates a reasonable goodness of fit. Results for all variables are as initially hypothesized economically. The "Price-Stickiness Theory" was supported by the results. However, the relationship between retail and F.O.B prices was not as widely asymmetric as the industry would have thought (the coefficients are quite similar).

Table 5. Statistical Results For The Ad-Lines Equation (Southeast Region).

Variable name	Mean Value	Standard Deviation	Parameter Estimate	T for H_0 : Parameter = 0
Intercept			768.94	2.22
Ad-buys expenditures	11,826.90	6,507.5	0.12	5.26
Lines lagged one period	3,788.70	2,465.80	0.33	5.13
Indicator variables for month				
October			1,844.82	4.39
May			-844.54	-2.12
June			-551.03	-1.28*
Indicator variables for marketing year				
1992			-1,271.89	-3.09
1993			-924.74	-2.26
1996			1,093.73	2.77
1997			2,720.33	5.86
1998			1,977.17	4.60
1999			1,097.25	2.64
February of 1992			-1,689.45	-4.23
December of 1994			3,870.72	3.14
Ad lines (dependent variable)	3,742.30	2,444.40		
CPI for food items	1.57	0.12		
$R^2 = 0.79$ $N = 115$	Durbin h test = 0.54			

* Non-significant at the 0.10 level.

The base period for the monthly and marketing-year indicator variables is those months (years) not appearing in these results.

Supply Behavior and Overall Impact on Average Industry Returns

Table 9 depicts the results obtained for the supply equation¹. The sign of the coefficient of each variable, the corresponding significance level of the estimated parameter, and the model R^2 supported our hypotheses. The R^2 of the supply model (0.810) indicated that most of the variability occurring in quantity supplied was accounted for by the explanatory variables (Table 9).

One of the most intriguing results of the supply equation is that the lagged-F.O.B.-price parameter estimate is negative (Table 9). However, when both the current month and past month effects are jointly analyzed the results make sense from the packer's perspective. Rising F.O.B. prices (both current and lagged) will cause an increase in the

current month's volume shipped. However, the increase will be muted as some packers anticipate further price increases and attempt to restrain sales to take advantage of those anticipated price increases by marketing higher quantities in future months. Conversely, a declining F.O.B. price will reduce the current month's quantity supplied. However, the decrease will be partially offset as some packers anticipate further declines and attempt to move additional quantities before profits vanish.

Logically, when lagged price and current price move in opposite directions the effect of the current F.O.B price on quantity supplied is amplified by the lagged-price effect. Mixed price signals may increase packer's uncertainty about the future, causing an exaggerated response to current market conditions.

Average industry returns are computed for all three systems and measured through benefit-cost ratios. In the case where the supply elasticity was used, higher average benefit-cost ratios were ob-

¹ The authors used several models of supply; however, the one presented in this article seemed the most statistically and economically defensible.

Table 6. Statistical Results For The Ad-Lines Equation (Southwest Region).

Variable name	Mean Value	Standard Deviation	Parameter Estimate	T for H_0 : Parameter = 0
Intercept			2,226.37	3.13
Ad-buys expenditures	6,227.40	3,723.90	0.03	1.83
Lines lagged one period	1,909.90	1,115.30	0.20	2.68
Lines lagged two periods	1,933.70	1,115.70	0.16	2.26
Retail price lagged one period	0.62	0.06		
Indicator variables for months			-1,564.72	-1.51
May			-842.49	-4.25
June			-819.06	-4.02
July			-814.94	-3.86
August			-527.51	-2.29
Indicator variables for marketing year				
1992			-823.19	-3.96
1993			-526.59	-2.50
1997			314.39	1.55
1998			225.49	1.08*
March of 1993			1,660.62	2.72
December of 1994			1,588.69	2.67
October of 1997 and 1998			3,034.70	6.94
February of 1998			1,218.06	2.01
Ad lines (dependent variable) ^a	1895.10	1,117.00		
CPI for food items	1.48	0.11		
$R^2 = 0.77$ $N = 115$				

* Non-significant at the 0.10 level

^aThe error term ($u_t = y_t - bX_t$) was also regressed against the variables shown in this Table and u_{t-1} . The pvalue of u_{t-1} was 0.261, indicating no problems of autocorrelation.

The base period for the monthly and marketing-year indicator variables is those months (years) not appearing in these results.

tained relative to the benefit-cost ratios generated by the full model and the single-equation model (Table 10).

Several interesting points emerge when comparing yearly estimates across models. First, the single-equation model projects returns to trade activities that are almost always below the results from the other models. The only exception occurs in 1994, when the single equation predicts a higher benefit-cost ratio than does the full model. The supply-elasticity approach also produced higher estimates of impact than did the full model for trade activities in all years except 1999.

A comparison of the standard deviations for each of the averages suggests that the use of less-complex models may not capture the full year-to-year effects. However, this is not a straight-line relationship as the standard deviation for the single-

equation result is greater than the same measure in the supply-model elasticity.

An intriguing pattern appears to occur in the results for radio and TV. The years 1994, 1996, and 1998 were very large crop years. The "off" years (1995, 1997, and 1999) had significantly smaller crops. In the short-crop years the full model projects greater returns to radio and TV advertising than does the elasticity of supply model. The reverse is true in the long-crop years. One possible explanation is that by using the elasticity of supply in lieu of a supply equation the adjustments that shippers typically make due to size of crop are not allowed to manifest themselves fully in the results.

Table 11 shows the relative differences among the average benefit-cost ratios. Assuming a supply elasticity of 0.47 (which is the actual elasticity obtained in the supply model empirically estimated

Table 7. Statistical Results For The Ad-Lines Equation (West Region).

Variable name	Mean Value	Standard Deviation	Parameter Estimate	T for H_0 : Parameter = 0
Intercept			3,716.07	10.61
Ad-buys expenditures	9,652.9	6,159.40	0.09	4.57
Lines lagged one period	4,131.70	2,288.90	0.17	2.62
Indicator variables for month				
November			-918.99	-2.32
December			-710.09	-1.88
April			-1,038.08	-2.60
May			-2,684.60	-7.39
June			-2,938.27	-7.65
July			-3,388.43	-8.46
August			-3,063.24	-7.38
Indicator variables for marketing year				
1992			-1,140.40	-3.42
1995			-978.84	-2.76
1997			730.06	1.97
1998			1,034.09	2.98
April 1995			4,588.36	4.22
March 1997			2,752.03	2.53
October of 1997			2,761.67	2.43
October of 1998			1,884.04	1.73
Ad lines (dependent variable)	4,075.80	2,281.50		
CPI for food items	1.53	0.12		
$R^2 = 0.83$ $N = 115$	Durbin h test = 0.48			

The base period for the monthly and marketing-year indicator variables is those months (years) not appearing in these results.

in our study), the benefit-cost ratios for the non-trade activities were overstated by an average 8.83%, while the benefit-cost ratios for the trade activities were overstated by 19.6% relative to the benefit-cost ratios obtained with the full interaction of demand and supply functions. The single-equation model significantly underestimates the ratios when compared to either of the other models.

Estimated Model Costs

The primary costs associated with this work included graduate assistant stipends, data entry and programming. In the single-equation approach, data entry costs are avoided because all of the data were electronically available from either the WAC or from secondary sources. However, significant time was needed to verify, correct, and organize the data

into usable form. The shipping data alone included over 1 million observations and the original data-entry patterns changed over time, requiring significant verification and correction. It is estimated that some 100 hours were needed for data verification, correction, and programming. Given that the project is completed in a summer and a semester (approximately 6 months), the single-equation system cost about \$21,000. Other expenses (travel, supplies, equipment) and faculty salaries add to this total. The final cost figure is in the range of \$25,000 to \$30,000, depending on the extent of expenses in the other category.

The cost of the full demand system of equations is more than double that of the single-equation system due to the expanded number of variables and the associated increase in verification, correction, and programming needed to create us-

Table 8. Statistical Results For The Retail-F.O.B. Price-Transmission Equation.

Variable name	Mean Value	Standard Deviation	Parameter Estimate	T for H_0 : Parameter = 0
Intercept			-0.243	-0.890*
Pretail _{t-1} *Midwest indicator	0.204	0.400	0.150	1.260*
Pretail _{t-1} *Northeast indicator	0.213	0.440	0.096	1.200*
Pretail _{t-1} *Southeast indicator	0.195	0.399	0.351	3.310
Pretail _{t-1} *Southwest indicator	0.185	0.374	0.234	2.890
Pretail _{t-1} *West indicator	0.194	0.385	0.345	3.630
Accumulative increases in F.O.B. prices (PFI)	0.686	0.302	1.018	9.180
Accumulative decreases in F.O.B. Prices (PFF)	-0.693	0.316	0.928	8.360
Wage x Midwest indicator	0.903	1.767	0.119	2.340
Wage x Northeast indicator	0.827	1.706	0.120	2.490
Wage x Southeast indicator	0.838	1.713	0.104	2.090
Wage x Southwest indicator	0.864	1.735	0.115	2.350
Wage x West indicator	0.890	1.757	0.070	1.440
Transportation cost (TC) x Midwest	0.882	1.723	0.115	2.880
Transportation cost x Northeast	0.816	1.678	0.155	3.500
Transportation cost x Southeast	0.827	1.687	0.088	2.050
Transportation cost x Southwest	0.849	1.702	0.092	2.270
Transportation cost x West	0.871	1.716	0.114	2.740
Mexican Crisis indicator (MC)			-0.006	-2.060
PC sales ^{0.05}	1.509	0.448	-0.034	-3.200
October			0.031	1.860
November			0.054	3.060
December			0.055	2.970
January			0.070	3.850
February			0.076	4.190
March			0.077	4.060
April			0.080	3.950
May			0.108	5.00
June			0.118	5.340
July			0.071	3.230
August			0.079	0.021
Retail Prices (Dependent variable)	0.990	0.1086	Durbin h = 2.15	
R2 = 0.715 N = 359				

*Non-significant at the 0.10 level

September is the base period for the monthly indicator variables.

Table 9. Statistical Results For The Supply Function.

Variable name	Mean Value	Standard Deviation	Parameter Estimate	T for H_0 : Parameter = 0
Intercept			65.313	1.310*
PFR_t (F.O.B. price)	0.331	0.049	498.261	3.900
PFR_{t-1}	0.329	0.057	-219.301	-3.220
Inventories in millions of lbs.	2229.000	1337.900	0.007	2.450
Exports lagged one period millions of lbs.	82.629	30.739	-0.278	-2.750
Apple producer prices paid index	1.032	0.178	-45.134	-2.590
Processing price per lb. lagged one period	0.053	0.045	-339.090	-2.880
T	6.500	3.467	78.508	8.580
T ²	54.167	46.292	-17.234	-11.970
T ³	507.000	553.900	0.949	13.710
Mexican exchange rate X Mcrisis ^a			1.642	2.210
Weighted Asian Exchange rates	17.408	1.713	2.341	1.890
Large crop year indicator	0.300	0.460	37.915	7.330
Indicator for November and December 1993 and January and February 1994 (calendar year)			-25.546	-2.240
Total supply in millions of pounds (Dependent Variable)	198.7	40.519		
$R^2 = 0.812$ $N = 119$		Durbin-Watson Test = 1.881		

* Non-significant at the 0.10 level

^aMcristis is an indicator variable, = 1 from January 1995 through August 1995 (calendar year), 0 otherwise.

able variables. Again, the principle cost is in data-base creation. Approximately 320 hours of programmer time was used to prepare the variables from the raw data provided by the WAC. Those variables were shipments, logos, lines, retail prices, WAC expenditures for all promotional activities except TV and radio, and expenditures by the advertising firm handling the WAC account. In this case, not all of the data from the early years of the study period were available electronically. Data entry of information for those early years cost nearly \$10,000. Assuming two years of graduate assistant stipends plus another \$12,400 for minimal faculty salaries and the miscellaneous categories identified above brings the estimated total cost to \$68,000.

The cost of the full model including a supply function was \$72,000. A full summer was added to allow for the estimation of the system and simulation of the full system to determine advertising and

promotion effects. The complete system, including the supply equation, does not require any additional data beyond the data used to estimate the system of demand equations.

In this particular study, and using this particular approach, the single-equation model is obviously much less expensive. However, the information available from that model is of limited value, as it fails to measure some of the market impacts of relevant WAC activities.

The other comparison is between the full demand system with and without the supply equation. Both capture the impact of WAC activities. The 6% increase in research costs to include the supply equation seems a useful expenditure given the improved estimates of impacts that result from accounting for supply-feedback effects in response to promotional efforts, which suggested mitigation/attenuation of the positive effects of promotional efforts.

Table 10. Average Industry Returns By Promotion Type.

Using Complete Supply Model			Assuming elasticity of Supply = 0.471 ^a B _{PFR} = 281.80		Single-Equation Model ^{b,c}
Crop Marketing Year ^d	Trade activities (demos, display, giveaway products, and other promotional activities, including ad buys)		Trade activities (demos, display, giveaway products, and other promotional activities, including ad buys)		Trade activities (demos, display, giveaway products, and other promotional activities, including ad buys)
	Non-trade activities (TV and radio)		Non-trade activities (TV and radio)		
1992	2.42	17.83	3.25	24.56	13.59
1993	3.07	22.67	3.71	29.82	15.26
1994	3.63	22.59	4.44	33.52	25.36
1995	4.20	28.35	3.96	30.19	19.66
1996	3.49	28.99	3.62	35.66	26.46
1997	3.91	30.02	3.58	33.25	15.74
1998	2.15	30.26	2.61	37.40	12.81
1999	2.64	39.62	2.51	39.09	13.01
Average	3.19	27.54	3.46	32.94	17.74
Std. Deviation	0.738	6.598	0.652	4.676	5.501

^a Actual elasticity of supply obtained in this study when evaluated at the mean level (PFR_i and PFR_{i-1} is used in when computing this elasticity).^b Calculated at the mean price.^c The coefficient for radio and TV was insignificant.^d September–August.

Table 11: Relative Differences Among Models (%).

	Non-Trade Activities	Trade Activities
Complete Model vs. Demand System with Σ_s	8.5	19.6
Complete Model vs. Single-Equation model	N/A	-35.6
Demand System with Σ_s	N/A	-46.1

It is necessary to point out that the cost estimates provided here do not represent the true full costs of the research activity. There is a substantial amount of subsidization of faculty salaries by the State that has not been included. The total cost, including faculty salaries, of the full system is probably at least 50% higher than the estimate shown here.

Conclusion

This paper reports the results of a case study analyzing the impacts of promotion and the advertising conducted by the Washington Apple Commission (WAC) using both single- and multi-equation systems with and without a complete model of supply response. The analyses are compared in terms of the comparability and coherency of results and in terms of the types of information that can be generated by the multi-equation model but not by the single-equation model.

The results of this study suggest that in terms of predicting the quantity effects of promotion expenditures, if one conditions on F.O.B. price levels, the effects of non-trade activities from the single equation are not statistically significant and seasonality is not a major factor in determining monthly demand. Conversely, within the multi-equation approach, results of this study suggests that non-trade activities *did have* a measurable impact on the demand of Washington Apples.

In terms of predicting the price effects of promotion expenditures, if one conditions on supply levels, the approaches provide similar predictions of price impacts. However, the simultaneous supply feedback is significant in the apple industry case, so by taking the interaction of supply and demand into account the more complex multiple-equation approach predicts notable supply response-induced mitigation in price increases origi-

nally induced by promotion efforts relative to when impacts of promotions are measured under scenarios of a fixed-supply function. Price alone does not reflect all the information necessary to coordinate supply and demand. Only if supply is fixed (e.g. by a quota) will the study of demand be sufficient to evaluate the effectiveness of advertising and promotion activities in shifting demand curves outward.

Supply response is usually a function of price and input costs associated with producing the commodity. However, depending upon the structure of the industry and the nature of the analysis (monthly, quarterly), supply may also respond to other external factors such as the ones considered in the formulation and empirical estimation of the supply function for Washington apples within the more complex multi-equation system. Ignoring these effects on supply response in the overall analyses may cause inferences regarding advertising and promotion returns to be notably biased, which in turn may result in a significant financial penalty for decision makers when industry returns fall close to break-even points. More generally, ignoring multi-equation systems may cause biased decisions with respect to a number of factors that are held constant or obscured in the single-equation analysis but that are modeled and simulated explicitly in the multi-equation system.

Actual cost estimates by type of analysis are provided in Table 11. The results of the case study provide an illustrative basis for assessing the necessity, as well as the benefits and costs, of conducting a detailed and complex multi-equation promotion evaluation relative to a simpler and more focused single-equation analysis of promotion effectiveness.

References

- Alston, J. M., J. A. Chalfant, J. E. Christian, E. Meng, and N. Piggott. 1997. *The California Table Grape Commission's Promotion Programs: An Evaluation*. Giannini Foundation Monograph Number 43. U.C. Berkley, CA.
- 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 Number 344. U.C. Berkley, CA.
- Carman, H. and K. Craft. 1998. *An Economic Evaluation of California Avocado Industry Marketing Programs 1961-1995*. Giannini Foundation Research Report Number 345. U.C. Berkley, CA.
- Chung, C., and H. Kaiser. 2000 "Determinants of Temporal Variations in Generic Advertising Effectiveness." *Agribusiness* 16,2:197-214.
- Erickson, G., R. C. Mittelhammer, R. T. Schotzko, and C. Seavert. 1997. "An Evaluation of the Effectiveness of Pear Advertising and Promotion: Final Report." The Pear Bureau, Portland, Oregon.
- Erickson, G. R. 1999. *Grower Returns to Winter Pear Promotion: A Nonparametric Analysis*. Unpublished Dissertation Thesis. Department of Agricultural Economics, Washington State University, Pullman, WA.
- Kinnucan, F. and O. Forker. 1987. "Asymmetry in Farm-Retail Price Transmission for Major Dairy Products" *American Journal of Agricultural Economics* 69,2:286-292.
- Nerlove, M and F. Waugh. 1961. "Optimal Advertising Policy under Dynamic Conditions" *Economica* 29:129-142.
- Van Voorthuizen, H. 2001. Unpublished Ph.D. Dissertation. Department of Agricultural Economics, Washington State University, Pullman, WA.
- Ward, Ronald W. 1993. "Washington Apple Advertising: An Evaluation Update." Food and Resource Economics Department, University of Florida, Gainesville, FL.