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The Allocation of Advertising and Research Dollars in the Florida Orange Juice Industry

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Abstract

This study considers the allocation of Florida citrus-grower money between advertising and research programs to maximize grower revenue net of program costs. The allocation depends on the impact of advertising on demand and the impacts of research on the cost of production and supply. A number of studies have estimated the impact of advertising on OJ demand, but little is known about the impact of research. Research on citrus greening, a disease that has no known cure, is examined in the present study. There are no past studies to reliably gauge the impact of this research. The approach taken here is to ask if a given amount of research dollars is needed to reduce average production costs by certain amount, then what should be spent on advertising based on past estimates of the elasticity of demand with respect to advertising. The optimal ratio of advertising to research dollars increases with the advertising elasticity and declines with the amount of research money needed to reduce average costs. The results of this study provide a range for this ratio based on different advertising elasticities and amounts of research dollars needed to reduce production costs. The approach provides an indication of the importance of advertising given expectations on the research needed to successfully fight this disease.

Introduction

The Florida citrus industry established, in 1937, a state marketing order which later evolved into the Florida Department of Citrus (FDOC). The purpose of the marketing order was to promote the consumption of citrus products produced in Florida. Today, the FDOC levies a tax on all citrus grown in the state which funds both demand enhancement and research programs. Until recently, most of the FDOC's programs were intended to expand the demand for Florida citrus products. This was accomplished through a generic advertising program that included television and print advertisement, point-of-purchase promotion, and educational programs that touted the health benefits of citrus consumption.

In 2005, citrus greening[1] was discovered in Florida. Citrus greening is a devastating disease for citrus trees. At present, there is no known cure other than tree eradication. Tree eradication is problematic since infected trees may be asymptomatic for up to two years after contracting disease. Growers following an eradication policy may not be successful in controlling the disease given this fact. Given the significance of the threat posed by citrus greening, the FDOC abruptly changed its policy in 2008 and began funding research related to control of

1. The disease is also known as Yellow Dragon and Huanglongbing (HLB).

citrus greening and citrus canker[1]. The question to be addressed in this paper relates to the implications of this change in policy. What is the optimal allocation of funds between advertising (demand enhancing) versus production research (supply enhancing) when the pool of money is generated through a self-imposed tax which itself negatively affects grower returns?

Previous Research

Both issues addressed in this paper: generic promotion and funding of production research have been the focus of previous papers. The book by Forker and Ward provides an overview of the economics of generic advertising. The case of generic advertising of orange juice, the primary citrus product produced in Florida, has been addressed by several authors including Capps, et al. (FABA), Ward et al., Brown and Lee, and Market Accountability Partnership (MAP). These authors found a positive relationship between the level of generic promotion expenditures and the demand for orange juice in the United States. Significant differences in the magnitude of the advertising elasticity were estimated, however, with Capps, et al. suggesting that the long-run generic advertising elasticity for U.S. orange juice demand was .42, while MAP suggests a short-run estimate of approximately .08.

Grower-funded production research efforts are generally categorized as returns to research. A study on post-harvest research in the Florida citrus processing sector found that this activity had a high rate of return (Shonkwiler and Stranahan). Studies on the gains from research and promotion for other commodities, generally relevant to the present citrus issue, have also been conducted (e.g., Wohlgenant; Chung and Kaiser; Chyc and Goddard; Cranfield; and Fuglie and Heisley).

In this paper, a model of the world orange juice (OJ) market is developed and simulated to examine the OJ advertising-research allocation issue. This model differs from previous efforts (e.g. McClain and Spreen, et al.) in that an explicit relationship between price and quantity supplied is assumed. In previous efforts, current price is assumed to affect current plantings of new trees which, in turn, affect future production. Therefore fluctuation in the bearing tree population explains fluctuation in production, although there is considerable year-to-year variance in per tree yield. Under this scenario, price and production are linked through investment in new trees and an explicit supply curve does not exist. Alternatively, in this paper, a long-run relationship between price and production is hypothesized. Investment in production research is assumed to shift this long-run supply curve although the exact phenomenon that affects the shift is not identified[2] .

A Model of the World OJ Market and Optimal Advertising and Research Expenditures

The world OJ model developed in this paper is comprised of two demand equations and two supply equations. The first demand equation is for the United States, given the focus of the study is on how advertising and research impact Florida grower revenue, as well as the fact that the United States is the largest OJ market in the world. The second demand equation is for the European Union, the second largest market, and other major foreign markets, all of which

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1. Citrus canker is another disease confronting the Florida citrus industry with no known cure. While a dangerous disease, the presence of citrus canker has more serious ramifications for fresh fruit suppliers compared to the threat citrus greening poses to processed fruit.

2. Shifts in the long-run supply curve could be the result of reduced tree mortality, increased yield, or decreased cost of production.

is referred to as the rest of the world (ROW). On the supply side, Brazil is the largest producer of OJ in the world accounting for over 50% of the world's production, while the United States is the second largest producer accounting for about 30% of the world's total. Over the last decade, Florida has accounted for 91% to 98% of the OJ produced in the United States Given the dominance of Florida and Brazil in world OJ supply, the two supply equations in the model are for Florida and Brazil production, respectively (a relatively small amount of other U.S. production is included with Florida production).
The United States is treated as a net importer of OJ, while the ROW is a treated as a net exporter following McClain (1989). The import-export equilibrium is determined by an excess-demand, excess-supply relationship. Formally, the model is specified as

- $q1 = b10 + b11\,(p + c) + b12\log(A)$ (U.S. OJ demand)
- $q2 = b20 + b21\,(p - t)$ (ROW OJ demand)
- $s1 = c10 + c11\,(p - m10 - m11\log(R))$ (Florida OJ supply)
- $s2 = c20 + c21\,(p - m20 - m21\log(R) - t)$ (ROW OJ supply)
- $q1 - s1 = s2 - q2$ (Equilibrium)
- $\pi = (p - m_{10} - m_{11}\log(R))\, s_1 - A - R$ (Florida net revenue)

where

- A and R are U.S. advertising and research dollars, respectively;
- q_1 and s_1 are the U.S. quantities of OJ demanded and supplied, respectively;
- q_2 and s_2 are ROW quantities of OJ demanded and supplied (Brazil), respectively;
- p is the Florida FOB price;
- t is the transfer cost from the ROW to the United States (U.S. tariff and transportation costs);
- c is the U.S. retail-FOB price margin, i.e., p + c is the U.S. retail price;
- m_{10} and m_{20} are fixed grower-FOB price margins for Florida and ROW, respectively;
- m_{11} and m_{21} are parameters associated with the level of research, i.e., $m_{10} + m_{11}\log(R)$ and $m_{20} + m_{21}\log(R)$ are U.S. and ROW grower marketing margins plus fruit production costs, respectively, and $(p - m_{10} - m_{11}\log(R))$ and $(p - m_{20} - m_{21}\log(R)-t)$ are the Florida and ROW grower prices, adjusted for the benefit of research expenditures, respectively; and
- the b's, c's, and m's are fixed parameters

The parameters b_{11} and b_{21}, the demand slopes with respect to price, are assumed to be negative; b_{12}, the advertising coefficient, is positive; c_{11} and c_{21}, the supply slopes with respect to price, are positive; m_{10} and m_{20} are positive. The parameters m_{10} and m_{20} include the cost of processing, harvest and hauling costs, and the cost of grove care maintenance including the cost associated with greening and canker. Thus $p - m_{10}$ is the net price received by growers in Florida and $p - m_{20} – t$ is the net price received in ROW (primarily Brazil). The parameters m_{11} and m_{21} reflect the savings that would be realized if the costs associated with greening and canker were diminished through research expenditures. Thus m_{11} and m_{21} are negative. The equilibrium price p is set such that excess demand in the United States (U.S. net imports) is equal to excess supply in the ROW (ROW net exports).

Advertising in the model is FDOC generic advertising expenditures. It is assumed that this advertising only impacts U.S. demand, with FDOC advertising messages occurring primarily in the United States. That is, with b_{12} being positive, an increase in advertising, A, results in an increase in U.S. demand as specified in equation (1).

Research is U.S. research expenditures. R is fully funded by Florida growers and therefore does not include federal and state research expenditures. It is assumed that the largest impact of this research is on the U.S. grower-FOB margin (m_{11}) related to production costs. In addition, U.S. research is assumed to have spillover effects on ROW grower-FOB margin (m_{21}). The marginal impacts of research on U.S. and ROW production are $\partial s_1/\partial R = -c_{11}m_{11}/R > 0$ and $\partial s_2/\partial R = -c_{21}m_{21}/R > 0$, respectively.

Advertising and research are specified in terms of logs, and thus have diminishing returns. This specification allows a solution to the revenue maximization problem which is to maximize equation (6) subject to the other five equations.

Equation (6) indicates Florida grower revenue net of advertising and research costs (R). Specifically, the term $(p - m_{10} - m_{11}\log(R))$ is defined as the on-tree price (net grower price) adjusted for the benefits of research expenditures. The parameter m_{11} is negative---an increase in research reduces production costs. Similarly, m_{21} is also negative.

The endogenous variables are p and the left-hand side variables of equations (1) through (4). The exogenous variables are A, R, c and t. The optimization problem is to determine the levels of A and R so as to maximize net revenue.

An increase in advertising, A, increases U.S. demand and price, while an increase in research R increases supply and decreases price. Changes in price, in turn, further impact demand and supply levels. Based on the solution for p from equations (1) through (4) and (5), the impact of advertising on price is[1]

$$(7) \quad \partial p/\partial A = (b_{12}/A) / (c_{11} + c_{21} - b_{11} - b_{21}),$$

while the impact of research on price is

$$(8) \quad \partial p/\partial R = (c_{11}\, m_{11} + c_{21}\, m_{21}) / R / (c_{11} + c_{21} - b_{11} - b_{21}).$$

Differentiating equation (6) with respect to A and R, the first order conditions for maximization of grower net revenue are[2]

$$(9) \quad \partial \pi/\partial A = \partial p/\partial A \;\; (s_1 + c_{11}\,(p - m_{10} - m_{11}\log(R))) - 1 = 0,$$

and

1. Substituting the right hand sides of equations (1) through (4) into equation (5), and solving for price, find the reduced form equation $p = (b_{10} + b_{11}\, c + b_{12}\log(A) + b_{20} - b_{21}t - c_{10} + c_{11}(m_{10} + m_{11}\log(R)) - c_{20} + c_{21}(t + m_{20} + m_{21}\log(R))) / (c_{11}+c_{21}-b_{11}-b_{21})$.

2. The second order conditions are $\partial^2\pi/\partial A\partial A < 0$; $\partial^2\pi/\partial R\partial R < 0$; and $(\partial^2\pi/\partial A\partial A)(\partial^2\pi/\partial R\partial R) - (\partial^2\pi/\partial A\partial R)^2 > 0$. In the empirical analysis these conditions were met.

(10) $\partial \pi / \partial R = (\partial p/\partial R - m_{11}/R)\,(s_1 + c_{11}\,(p - m_{10} - m_{11}\log(R))) - 1 = 0.$

The ratio of optimal advertising to research expenditures can be found by equating equations (9) and (10) and solving for A/R, using equation (7) and (8), i.e.,[1]

(11) $A/R = b_{12} / ((c_{11}\, m_{11} + c_{21}\, m_{21}) - m_{11}(c_{11} + c_{21} - b_{11} - b_{21}))$.

The first term on the right-hand-side of equation (9), $\partial p/\partial A\,(s_1 + c_{11}\,(p - m_{10} - m_{11}\log(R)))$, is the marginal revenue with respect to advertising, which is positive given that the impact of advertising on price, $\partial p/\partial A$, is positive, along with the other parameter assumptions and the condition that the net price term, $(p - m_{10} - m_{11}\log(R))$, is positive. The second term, -1, is the negative of the marginal cost of advertising. Advertising expenditures are increased until the marginal revenue of advertising equals its marginal cost.

In equation (10), the first term on the right hand side is the marginal revenue of research. This term can be decomposed into two parts. The first part is $(\partial p/\partial R)\,(s_1 + c_{11}\,(p - m_{10} - m_{11}\log(R)))$, which is always negative, given the impact of research on price, $\partial p/\partial R$, is negative, along with the other parameter assumptions. The second part of the marginal revenue of research, $(-m_{11}/R)\,(s_1 + c_{11}\,(p - m_{10} - m_{11}\log(R)))$, is positive assuming research negatively impacts the margin ($m_{11} < 0$). At the optimal level of research the second part must exceed the first part (in absolute value) for marginal revenue to be positive, and, as in the case of advertising, research expenditures are increased to the point where the marginal revenue of research equals its marginal cost. The model is solved for given values of the parameters. A critical issue is that prior estimates on the impacts of greening research on the Florida and ROW, marketing-margin/ production costs (m_{11} and m_{21}) are not available, with greening being a new disease to Florida, and no cure for this disease having been found in other citrus producing regions. The approach taken here is to assume that a given level of research expenditures will reduce the average cost of greening and canker to a negligible level. This assumption is then used to set m_{11} and m_{12}, or the curvature of the price-margin responses. Generally, the optimal research-expenditure level, based on this setting of the model, will not be the same as the initial level assumed and may be significantly different in some cases, as the empirical results indicate. Nevertheless, the assumption on research expenditures has a strong influence on the optimal level found. To examine this issue, alternative assumptions on the level of research expenditures are considered. Thus, the results of this study do not indicate the optimal level of research, but to what extent advertising is required to support grower returns in an environment where substantial greening research is needed.

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1. The sequence of results for this solution using basic algebraic operations are

$\partial p/\partial A\,(s_1 + c_{11}\,(p - m_{10} - m_{11}\log(R))) - 1 = (\partial p/\partial R - m_{11}/R)\,(s_1 + c_{11}\,(p - m_{10} - m_{11}\log(R))) - 1,$

$\partial p/\partial A = (\partial p/\partial R - m_{11}/R),$

$A/R = ((\partial p/\partial A)A) / ((\partial p/\partial R - m_{11}/R)R)$

$A/R = b_{12} / (c_{11} + c_{21} - b_{11} - b_{21}) / ((c_{11}\, m_{11} + c_{21}\, m_{21}) / (c_{11} + c_{21} - b_{11} - b_{21}) - m_{11}),$

$A/R = b_{12} / ((c_{11}\, m_{11} + c_{21}\, m_{21}) - m_{11}(c_{11} + c_{21} - b_{11} - b_{21}))$.

Equations (7) and (8) are used to find result iv) from iii).

Empirical Specification

As noted elsewhere, because citrus greening is a new disease, virtually no data is available to allow econometric estimation of the model. Therefore the approach taken here is to use parameter values estimated by other authors for the demand side of the model and assume reasonable values for the supply side of the model. Then, senstivity analysis is conducted in a comparative statics framework to examine the impact of alternative parameter values on the model.

The values of the demand slopes b_{11} and b_{21} are based on U.S. and ROW demand elasticities reported by Brown, et al. Initially, U.S. and ROW demand levels were set at 1,300 and 1,850 million single strength (SSE) gallons, respectively; price p was set at \$1.50 per SSE gallon; and the retail-FOB margin c was set at \$3.75 per SSE gallon. The slope b_{11} is the U.S. retail demand elasticity (-.70) times U.S. gallons divided by the U.S. retail price, while the slope b_{21} is the ROW FOB demand elasticity (-.34) times ROW gallons divided by the FOB price. The parameter b_{12} was set based on advertising elasticities, $(\partial q_1/\partial A)(A/q_1)$, estimated by FABA and MAP. A range of advertising elasticities were considered: .08, .25 and .42. The initial value of advertising was set at \$30 million. The elasticity $(\partial q_1/\partial A)(A/q_1)$ times the initial value for q_1 yields $(\partial q_1/\partial A)A$, which is treated as an approximation of the volume demanded due to advertising; this, in turn, is divided by log(A) to obtain b_{12}. The intercepts b_{10} and b_{20} are determined as the residuals, based on the initial values.

The supply slopes with respect to price are based on long-run supply elasticity estimates of .25 for Florida and .50 for the ROW. These values are based on the model in the FDOC (2007) report. The U.S. (ROW) long-run supply elasticity times the supply level s_1 (s_2), divided by the grower price ($p-m_{10}$ or $p-m_{20}-t$), yields c_{11} (c_{21}). Initial values for s_1 and s_2 were 1,050 and 2,100 million single strength (SSE) gallons, respectively. The model thus reflects long-run responses for given levels of advertising and research sustained over time.

The margins m_{11} and m_{21} are based on estimates of additional production costs due to citrus greening and canker made by Muraro. Two estimates were considered---greening and canker increase average production costs by \$.25 and \$.50 per SSE gallon. These additional costs (Δc) were divided by the log of an assumed research level to obtain the parameters m_{11}. That is, given R, the parameter m_{11} is approximated by $-\Delta c/\log(R)$. For example, when $\Delta c = -.25$ and R=\$1 million, the minimum research level assumed to occur, the term $m_{11} \log(1) = 0$; when R=\$30 million, $m_{11} \log(30) = -.25$, i.e., to approximate the curvature of the price margin response to research, \$1 million spent on research per year will not reduce the average cost of greening, but \$30 million (sustained over time) will reduce the cost by \$.25/gallon. The parameter m_{21} was assumed to be 75% the level of m_{11}, assuming spillover effects are only partial.

Assuming the cost of greening is \$.25 per gallon (\$.50 per gallon), the margins m_{10} and m_{20} were set at \$.85 (\$1.10) per SSE gallon and \$.60 (\$.85) per SSE gallon, respectively, to reflect processing, and pick and haul costs (industry estimates). The U.S. tariff (FCOJ) was set at \$.30 per SSE gallon and transportation costs were set at \$.10 per SSE gallon.

It is unknown how much research will be needed to overcome greening and the degree that research can save trees and increase productivity; one can only speculate. In this study, three baseline levels of research expenditures (R) are considered---\$30 million, \$45 million, and \$60 million per year. The baseline research expenditure levels are assumed for the scenarios where the average greening/canker cost is \$.25 per gallon. When the average greening/canker cost is \$.50 per gallon, assumed research expenditures are doubled. Associated price-margin, research elasticities are m_{11}/m_1, where m_{11} is calculated as discussed elsewhere assuming a research expenditure level, and $m_1 = m_{10} + m_{11}\log(R)$ or the U.S. FOB-grower price margin; i.e., $m_{11} = \partial m_1/\partial \log(R) = (\partial m_1/\partial R)R$, and thus the elasticity of this margin with respect to research is $\partial m_1/\partial \log(R)/m_1$ or m_{11}/m_1. Note that the absolute value of this elasticity varies inversely with the assumed level of R underlying it. The margin elasticity evaluated at the initial, without-research margin level ($.85/gallon or $1.10/gallon) is used to define a scenario.

Eighteen scenarios were considered based on the three advertising elasticity levels, three research levels or implied research elasticity levels mentioned above, and two greening/canker cost assumptions.

In summary, less is known about how the supply price margin might respond to a given level of research expenditures compared to how demand responds to a given level of advertising expenditures. Thus, the model provides a better indication of optimal advertising expenditures associated with an assumed research level, rather than predicting the optimal research level.

Empirical Results

Optimal advertising and research expenditures for the various scenarios are shown in Table 1. Relatively large amounts of advertising are needed to optimize grower revenue, except for the low-advertising elasticity scenarios. For the mid and high advertising elasticity assumptions along with the assumption that greening and canker costs are $.25 per SSE gallon (scenarios 4 through 9), advertising expenditures are greater than research expenditures, although research expenditures are relatively large. For the low advertising elasticity assumptions (scenarios 1-3), research expenditures exceed advertising expenditures.

Table 1. Optimal Advertising and Research Solutions Based on Alternative Elasticity and Cost Assumptions.

Scenario	Assumed Value			Optimal Value							
	Cost of Greening[1]	Advert. Elasticity %? q/ %? A	Research Elasticity %? m/ %? R	Advert.	Research	FOB Price	Fl Grower Price[2]	U.S. OJ Sales mil. ga.	ROW OJ Sales mil. ga.	U.S. OJ Prod. mil. ga.	ROW OJ Prod. mil. ga.
	$/ga.			mil. $	mil. $	$/ga.	$/box				
1	0.25	0.08	-0.09	14.3	38.4	1.52	6.03	1273	1840	1067	2047
2	0.25	0.08	-0.08	14.2	34.0	1.55	5.94	1269	1830	1061	2038
3	0.25	0.08	-0.07	14.1	31.5	1.56	5.89	1267	1825	1058	2033
4	0.25	0.25	-0.09	45.2	38.8	1.54	6.16	1332	1832	1075	2089
5	0.25	0.25	-0.08	44.8	34.4	1.57	6.07	1327	1822	1070	2080
6	0.25	0.25	-0.07	44.6	31.9	1.58	6.02	1324	1817	1066	2075
7	0.25	0.42	-0.09	77.4	39.6	1.58	6.39	1439	1817	1090	2166
8	0.25	0.42	-0.08	76.8	35.1	1.60	6.31	1433	1807	1084	2156
9	0.25	0.42	-0.07	76.5	32.5	1.61	6.26	1430	1802	1081	2151
10	0.50	0.08	-0.11	9.9	64.9	1.58	6.36	1252	1815	1111	1956
11	0.50	0.08	-0.10	9.8	58.3	1.62	6.24	1244	1798	1100	1943
12	0.50	0.08	-0.09	9.7	54.3	1.65	6.18	1240	1788	1093	1935
13	0.50	0.25	-0.11	31.1	65.2	1.59	6.40	1288	1812	1116	1984
14	0.50	0.25	-0.10	30.7	58.6	1.63	6.29	1280	1795	1104	1971
15	0.50	0.25	-0.09	30.4	54.6	1.65	6.22	1275	1785	1097	1963
16	0.50	0.42	-0.11	52.8	66.0	1.60	6.51	1373	1806	1126	2052
17	0.50	0.42	-0.10	52.1	59.3	1.65	6.39	1364	1789	1115	2038
18	0.50	0.42	-0.09	51.7	55.3	1.67	6.32	1358	1779	1108	2030

[1] The increase in the average Florida production cost related to greening and canker (Muraro).

[2] On-tree price: the FOB price minus the Florida grower margin times 6.4 SSE gallons per box, i.e., $(p-m_1)*6.4$.

The model solutions when the average cost of greening and canker is increased to $.50 per SSE gallon along with associated parameter settings (scenarios 10-18), indicate lower levels of advertising expenditures and higher levels of research expenditures. Although relatively high, advertising expenditures are less than research expenditure for these scenarios.

Price (FOB) ranges from $1.52 to $1.67 per SSE gallon. Remembering that U.S. OJ supply was initially set at 1050 million SSE gallons, the supply response resulting from research expenditures is relatively small with U.S. OJ supply ranging from 1,058 million to 1,126 million SSE gallons across the 18 scenarios. The effect on ROW supply in most cases is negative with OJ supply ranging from 1,935 million to 2,166 million SSE gallons compared to the initial specification of 2100 million SSE gallons. U.S. OJ consumption ranges from 1,240 million to 1,439 million SSE gallons (the effects of higher prices are offset, in part, by the effects of higher advertising). ROW consumption ranges from 1,779 million to 1,840 million SSE gallons at the higher prices projected.

The ratio of advertising to research expenditures based on equation (11) are shown in Table 2.[1] This table illustrates how the ratio changes for different assumptions on the levels of research expenditures and greening/canker costs. A higher advertising elasticity suggests a higher advertising/research ratio since advertising expenditures, in this case, are more effective in shifting demand. Higher costs for greening/canker ($.50 per gallon versus $.25 per gallon reduces A/R as expenditures on research now have a greater effect on growers' returns given the higher cost of the diseases

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Table 2. Ratio of Optimal Advertising-to-Research Expenditures, Based on Alternative Assumed Param Values.[1]

Assumed Research Expend. (R)	Cost of Greening/Canker	Ratio of Advertising/Research Expenditures: A/R		
		Advertising Elasticity		
mil. $	$/ga.	0.08	0.25	0.42
10	0.25	0.25	0.79	1.32
20	0.25	0.33	1.02	1.72
30	0.25	0.37	1.16	1.95
40	0.25	0.40	1.26	2.12
50	0.25	0.43	1.34	2.25
60	0.25	0.45	1.40	2.35
70	0.25	0.46	1.45	2.44
80	0.25	0.48	1.50	2.52
90	0.25	0.49	1.54	2.59
100	0.25	0.50	1.57	2.65
10	0.50	0.13	0.39	0.66
20	0.50	0.16	0.51	0.86
30	0.50	0.19	0.58	0.98
40	0.50	0.20	0.63	1.06
50	0.50	0.21	0.67	1.12
60	0.50	0.22	0.70	1.18
70	0.50	0.23	0.73	1.22
80	0.50	0.24	0.75	1.26
90	0.50	0.25	0.77	1.29
100	0.50	0.25	0.79	1.32

[1] Price margin parameters are dependent on assumed research expenditures, and cost of greening and canker; the advertising parameter is based on the advertising elasticity; other parameters are fixed, a slightly different value than in Table 1.

1. Some model parameters underlying the results in Table 2 have a different setting than in Table 1.

Concluding Remarks

In this study, a long-run model of the world market was developed to examine the optimal advertising-research mix to maximize Florida grower revenue net of the costs of these activities. The model is based on assumed coefficients reflecting the impacts of prices, advertising and research. The effects of prices on demand and supply, as well as the effect of advertising on demand, were set based on findings of prior studies. The effect of research on supply is less certain, and a range of research effects was considered. A range of advertising effects was also considered given the study's focus. The model solutions for the various advertising and research assumptions considered indicate that in face of large research expenditures needed to combat greening and canker, considerable advertising expenditures are also needed to maintain Florida grower revenue.

The need for additional research on this subject is clear. Work is needed to better understand the effect of research expenditures on m_{11}. This study ignored research expenditures by public sector entities, both the state and federal government. It also ignored research expenditures in other countries, in particular, Brazil, which remains the largest supplier of OJ to the world market.
Issues related to the dynamics of fruit tree production were also ignored given the long-run assumption of the model. If the solution to greening is a disease resistant variety/rootstock, then considerable investment will be needed to retrofit the industry to disease resistant trees. Both the cost of this investment as well as its speed in finding a solution will be of considerable interest and would require a dynamic model for analysis.

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