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LONG-RUN IMPACT OF ORANGE-JUICE GENERIC ADVERTISING

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Introduction

This paper discusses the long-run impact of generic advertising for orange juice (OJ) in the United States. OJ generic advertising is conducted by the Florida Department of Citrus (FDOC), with Florida being the largest orange and OJ producing state in the United States and the second largest orange and OJ producing region in the world following the state of Sao Paulo, Brazil. ("Citrus Summary," Florida Agricultural Statistics Service (FASS), and Food and Agriculture Organization (FAO) of the United Nations). Florida and Sao Paulo collectively account for over 80 percent of world OJ production with Sao Paulo dominating world trade, but Florida being the primary supplier to both the United States and Canada (FAO).

Long-run generic adverting estimates are made in context of a world supply and demand model for OJ. On the supply side, the model focuses on Florida and Brazil OJ production, while the demand side focuses on the U.S. market, the largest in the world. Other world production and demand for OJ are included in the model through a rest of the world (ROW) category.

The analysis focuses on changes in supply and demand over time. Changes or shifts in OJ demand due to advertising are based on previous research (Panel of Economists (Ward et al.); Forecasting and Business Analytics or FABA (Capps et al); Brown and Lee; Brown (2003)). OJ supply in a given season is beginning inventory plus world orange production which is determined by bearing tree populations in Florida, Brazil and the ROW, along with growing conditions. OJ

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[1]Report prepared by Mark G. Brown, Economist, Florida Department of Citrus; Robert P. Norberg, Director of Economic Research, Florida Department of Citrus; Thomas H. Spreen, Professor and Chair, Food and Resource Economics Department, University of Florida.

supply is allocated across the world based on the strengths of market-specific demands, which in the case of the U.S. market is dependent on generic advertising.

In upcoming years, Florida and Brazil orange production levels are expected to be constrained by diseases and other factors. Citrus canker and citrus greening are both present in commercial orange groves in Florida and Brazil. Citrus canker has also been found in Florida citrus nurseries, and much of the Florida nursery tree stock has been destroyed. Availability of nursery trees will be severely limited for several years. Other diseases are also present such as the citrus Tristeza virus in Florida and Sudden Death in Brazil. In addition, land development in Florida is expected to constrain production; and, in some parts of Brazil where oranges compete with sugar cane for land use, high sugar prices are expected to stimulate sugar cane production and, in turn, limit orange production. In the short run, advertising increases demand which in turn increases price; in the long-run, the price change increases supply, dampening or reducing the initial price increase. To the extent Florida and Brazil OJ supplies are constrained, this dampening effect will be reduced.

The impact of FDOC generic OJ advertising was previously studied in 2003 by Forecasting and Business Analytics or FABA (Capps et al.). Their model linked the U.S. market to the world through import supply and export demand equations. The difference between the FABA study and the present one centers on the production constraints mentioned above and Brazil supply. At the time of the FABA study, future production was not expected to be constrained as presently thought; and in the FABA study, Brazil OJ supply for export was specified as a linear function of price and time variables, in contrast to the supply specification in the present study which is based on the Brazil tree population and planting equations. Both the present study and the FABA study based

Florida orange and OJ production on Florida's orange tree or acreage population, using estimated planting equations in which tree or acreage planting levels are positively related to the price of OJ. The short-run impact of advertising on price stimulates orange plantings in Florida and Brazil (OJ production in the ROW is assumed to grow moderately). There is a lag of three years for a newly planted tree to become productive.

Historical Background

In 1935, the Florida Department of Citrus was created through a state marketing order and initiated advertising programs to expand the demand for Florida citrus products in the United States. In the 1934-35 season, Florida produced 15.6 million 90 pound boxes of oranges, nearly all of which was sold fresh. The advent of frozen concentrated orange juice (FCOJ) after World War II provided a new impetus for the industry. FCOJ provided a means to (1) store OJ from the harvest season into other time periods, (2) provided a way to produce a product with a consistent taste, and (3) offered new modes of transport and new retail package alternatives to the consumer. By the 1950-51 season, orange production was 67.3 million boxes with 62% being processed. By the 1970-71 season, orange production had grown to 142.3 million boxes, more than double 20 years earlier, with about 90% processed.

By 1970, however, other factors had surfaced which ultimately would impact the industry. Retail consumption of orange juice began shifting from purchase of FCOJ towards ready-to-serve reconstituted orange juice (known as recon). After the devastating freeze of 1962, Florida citrus interests helped initiate FCOJ production in Sao Paulo, Brazil. The decade of the 1970s, however, saw increasing citrus production in the State of Florida with orange production peaking at 206.7 million boxes in the 1979-80 season.

The decade of the 1980s saw successive freezes in 1981 and 1982, followed by the massive freezes of December 1983 and January 1985. As recovery began from those freezes, another destructive freeze came again in December 1989. Citrus production plummeted. The orange crop in 1989-90 was 110.2 million boxes. Given Florida's dominance in world citrus production at that time, the freezes of the 1980s were followed by an extended period of high prices for all citrus varieties. Florida saw its industry shift south into the flatwoods area of southwest Florida. Consequently, tree numbers rebounded and production recovered. In the 1997-98 season, a new production record was established at 244 million boxes of oranges.

During this same period, citrus production in other countries expanded as well. Production in Sao Paulo state, Brazil grew rapidly. By the mid 1990s, Sao Paulo replaced Florida as the largest producing region for orange juice. Rapid growth in production was also observed in Mexico, Belize, Costa Rica, and Cuba among others. Belize and Costa Rica benefitted from the signing of the Caribbean Basin Economic Recovery Act (also known as the Caribbean Basin Initiative or CBI) which eliminated the tariffs imposed on U.S. imports of orange juice, other fresh and processed citrus products, among other goods, from CBI countries. According to data from the Food and Agriculture Organization (FAO) of the United Nations, world orange production increased from an annual average of 40 million MT over the 1986-88 period to over 58 million MT over the 1996-98 period.

With rapid growth in world orange production, prices declined. These lower prices served to slow the tree planting process in all major citrus production regions including Florida and Sao

Paulo. With a near record Florida orange crop of 242 million boxes in the 2003-04 season, prices fell to levels not seen in Florida since the 1970s. The hurricanes that visited Florida in the fall of 2004 caused a rapid shift in the opposite direction in the supply-demand balance. These hurricanes were also responsible for the spread of citrus canker throughout much of the commercial citrus producing region of the state. With another hurricane crossing peninsular Florida again in 2005, prices increased to higher levels with the cash market for processed oranges reaching levels comparable to the freeze-affected years of the 1980s.

Model

A model of the world orange juice market was originally developed by McClain in 1989. Since that time it has been modified and updated several times including Spreen et al. (1992) in an analysis of the impact of the North American Free Trade Agreement (NAFTA) on U.S. citrus growers and Spreen et al. (2003) in an analysis of the effects of the proposed Free Trade Area of the Americas (FTAA).

The modeling approach used in these studies was modified and adapted for this study. The world OJ model is comprised of general relationships between OJ supply, demand and prices in the world. Econometric estimates of these relationships are then used to simulate the model. The model includes explicit supply sub-models for orange juice produced in Florida and Sao Paulo, Brazil.

This model used herein is a modification of the Spreen et al. (2003) model in that it does not explicitly consider not-from-concentrate orange juice as a distinct product from reconstituted from concentrate orange juice. Aggregation of these two products into a single product greatly simplifies the calculation of a price equilibrium. Demand for orange juice in the United States and the rest of the world are included in the model as well as inventory adjustments (juice inventories represent a demand for the present season and supply to the next season). Prices in the model are based on aggregate world supply and demand relationships. The current price is determined by (a) calculating the change in aggregate supply from the previous to current period, (b) calculating the assumed shift in aggregate demand (price constant) from the previous to current period, and (c) adjusting price to equate these supply and demand changes: if the supply change equals the demand change, price is unchanged; if the supply change is greater than (less than) the demand change, price is decreased (increased) until quantity demanded increases (decreases) sufficiently to eliminate the excess supply (excess demand), using demand elasticities across markets to determine the quantity responses to price. Although the model is based on one OJ price (the Florida FOB for bulk FCOJ), other OJ prices across markets and product forms would generally be expected to differ from the Florida FOB price, depending on transportation costs, tariffs, quality premiums and other factors. The margins between the Florida FOB price and the other prices, however, are assumed to be constant, and a change in the Florida FOB price results in the same change in the other OJ prices. This modeling approach is the same as taken by McClain.

The model takes as input the existing tree inventory in Florida and uses yields on a per acre basis to predict the Florida orange crop for the present season. Fresh utilization is deducted and using historical juice yields, the remaining orange production is converted to pound solids of juice. A similar process is used to predict orange and orange juice production in Sao Paulo, Brazil. Brazilian juice is allocated between the United States and the rest of the world (primarily the European Union). Juice from Florida and Sao Paulo constitute the bulk of the supply to the U.S.

market. Orange-juice production from Mexico, Costa Rica, Belize and other countries are part of aggregate world supply and some of this supply may be imported to the U.S. market, although not specifically tracked here—U.S. imports are calculated as a residual.[2] Based on demand relationships estimated by Brown et al. (2004; including updates), current year U.S. supply is allocated between current year consumption and inventory. The demand equations include a one percent annual increase in U.S. orange juice demand and two percent annual increase in demand in the ROW. To examine the impact of generic advertising, scenarios where U.S. demand additionally changes (one time) by 5%, 7.5% and10% are considered. Once an FOB price for FCOJ in the United States is determined, this price is used to predict new plantings in Florida in the next season. The tree inventory is aged one year and adjusted for death loss. A similar set of calculations is conducted for Sao Paulo. A major distinction between new plantings in Florida and Sao Paulo is that in the Sao Paulo equation, a ratio of orange prices and sugar prices is used to predict new plantings to account for the strong competition between oranges and sugarcane for agricultural land in Sao Paulo. After the tree inventory has been adjusted, the model moves to the next season and the process outlined above is repeated. Inventory accumulated from the previous season represents supply to the following season.

To account for the presence of citrus canker and greening, modifications to the model were made to per acre yields (canker) or death loss (greening). The new tree planting equation is also modified to reflect shifts in the revenue stream resulting from the presence of these diseases. Similarly, increased prices for undeveloped land are handled through a shift in the new tree planting equation.

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[2] U.S. imports are calculated as U.S. consumption minus Florida beginning inventory minus U.S. production (from Florida and other U.S. citrus producing states) plus U.S. exports plus Florida ending inventory.

A formal description of the model is provided in the Appendix.

Results

The model was simulated based on supply constraints assumed in the study "An Economic Assessment of the Future Prospects of the Florida Citrus Industry," by Spreen et al. (2006). In that and the present studies, Florida is subject to four supply constraints: (a) reduced acre yields as a result of citrus canker, (b) increased acre loss rates due to canker and greening, (c) reduced nursery trees and planting levels in the next several years (through the 2008-09 season) due to canker, and (d) reduced planting levels as a result of increased grove costs due to canker and greening, as well as higher land costs. Brazil is subject to two constraints: (a) increased tree loss rates due to greening, and (b) reduced tree planting levels as a result of higher sugar prices. These constraints are discussed in detail in the study by Spreen et al. (2006).; the constraints for their scenario 9 are imposed in the study here. In the Spreen et al. study (2006), orange production levels in Florida and Sao Paulo under the constraints mentioned above are projected to be 16% and 36% lower in the 2020-21 season, respectively, compared to the production projections without the constraints except those for Florida citrus canker (since this disease is now widely present in Florida, the canker constraints were maintained in the study by Spreen et al. (2006)).

The current study focuses on the impact of advertising on the price of OJ. Projections of the FOB price for bulk FCOJ for the upcoming 25 years (2006-07 to 2030-31) are made for three alternative assumptions: U.S. OJ gallon sales decrease by 5.0%, 7.5% and 10.0%, respectively, without advertising, with prices and other factors constant (Table 1). These assumptions, as mentioned earlier, are based on previous research (Panel of Economists (Ward et al.); FABA (Capps et al.); Brown and Lee; Brown (2003)). In the FABA study, advertising was measured as a goodwill or stock variable with a two-year lag structure based on annual data. That is, if advertising were ended today, the goodwill variable would become zero in three years. The Brown and Lee, and Brown (2003) studies were based on weekly data and found a shorter advertising lag structure of about 1 to 2 years. Following these studies, discontinuing advertising is assumed to decrease demand by 66% (33%, 3.5%) in the first (second, third) year without advertising.

The impact of the constraints is immediately noticeable with price increasing from $1.45/SSE gallons in 2006-07 to $2.26/SSE gallon in 2030-31, for the base scenario (advertising impacts demand). Similar but lower price projections are made for the without- advertising scenarios (Figure 1). In the first season without advertising, 2006-07, price decreases by 2.8 cents/SSE gallon, 4.2 cents/SSE gallon and 5.7 cents/SSE gallon, for the 5.0%, 7.5% and 10.0% reduced-demand, scenarios, respectively (Figure 2). In 2007-08, the without-advertising price is 4.7 cents/SSE gallon, 7.0 cents/SSE gallon and 9.3 cents/SSE gallon lower than the base or with-advertising price, for the 5.0%, 7.5% and 10.0% scenarios, respectively. The price differences moderately increase in the next season, and then are largely maintained for a few year before tapering off relatively slowly as orange tree planting levels and OJ supplies are reduced in the long-run. In 2030-31, the without-advertising price is 1.1 cents/SSE gallon, 1.7 cents/SSE gallon and 2.3 cents/SSE gallon lower than the base, for the 5.0%, 7.5% and 10.0% scenarios, respectively.

Similar price impacts due to advertising were found in the study by the Panel of Economists (Ward et al.) which showed that for price impacts in the range estimated in the present study the benefits of advertising significantly exceeded the associated costs (net benefit/cost ratios ranged from

1.5 to 3.8). Thus, the present results continue to support these earlier findings that advertising was effective in enhancing grower returns.

Moreover, the price impact and associated benefits are maintained for a number of years with the supply constraints. Eventually, though, this impact is dampened, with reestablishment of the Florida orange tree nursery industry (2009-10), prices stimulating orange tree planting levels, and newly planted trees maturing and bearing increasing amounts of fruit with age.

Estimates without the supply constraints are shown in columns 5 and 6 of Table 1. Column 5 shows projected prices for the with-advertising base scenario, while column 6 shows prices for the without-advertising scenario assuming a 10% decrease in demand. The impact of the supply constraints can be seen by comparing these unconstrained estimates with the corresponding constrained estimates in columns 1 and 4.

Notice first that the price estimates are much lower if supply is unconstrained. With-advertising, the FOB price with supply unconstrained is in the $1.33/SSE gallon to $1.47/SSE gallon range, versus the $1.45/SSE gallon to $2.28/SSE gallon range with supply constrained. The impact of advertising on price (difference between the with- and without-advertising price projections) is about the same for the constrained and unconstrained projections for the initial upcoming years, but without supply constraints, the impact of advertising on price vanished in about 14 years (2020-21). In contrast, with supply constrained, the impact of advertising on price is still about 4.1 cents/SSE gallon in 2020-21 and 2.3 cents at the end of the 25 year projection period. That is, the benefits of generic advertising last longer with the supply constraints .

Of course, there are many other factors that may impact supply and demand in upcoming years in addition to those discussed above. For example, supply may shift due to growing conditions and yield variation (e.g., the FDOC estimated the 95% confidence interval for Florida orange production based on yield variation alone at over +/- 20% around the average), while demand may shifts due to heath concerns and fads such as the recent consumer demand trend related to low-carbohydrate diets. Such shifts could significantly change the price projections made here.

Grower costs can be expected to increase significantly in upcoming years as a result of additional grove care needed to fight citrus canker, greening and other diseases, as well as increased land values (Spreen et al., (2006)). Staying in business has been increasingly difficult in recent years for many Florida orange producers with their earnings near the breakeven level or for some insufficient to cover full costs, so that these cost increases by themselves will make survival more difficult. Thus, with advertising providing price support that may persist longer in the supply constrained environment expected in the future, growers will be more likely to stay in business to the extent the price increases that are projected in this report are realized and offset the cost increases.

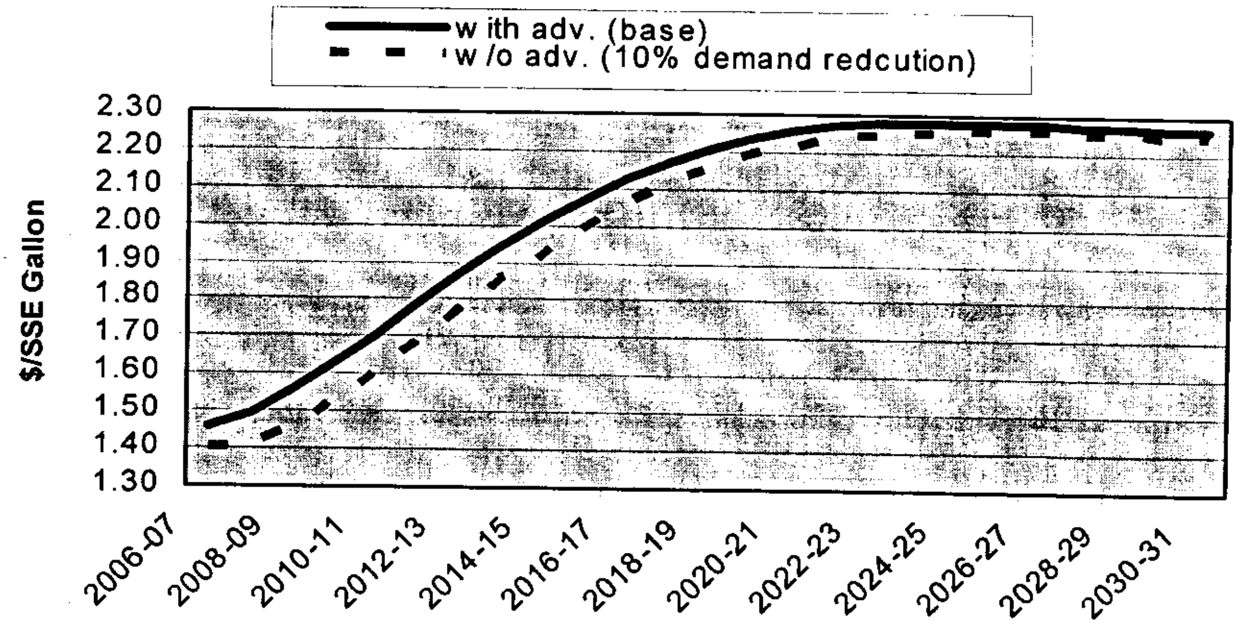
Concluding Remarks

To the extent Florida and Brazil OJ supplies are constrained in upcoming years, OJ prices should be significantly higher than otherwise. Moreover, with supplies constrained the impact of advertising on price will persist longer than otherwise. Advertising tends to increase price which, in turn, stimulates supply, dampening the initial price increase in the long-run. Restricting this dampening effect tends to maintain the price benefits due to advertising. For a 10% shift in demand due to advertising, the unrestricted dampening effect is estimated to eliminate the advertising price impact in about 14 years, whereas when supplies are restricted the impact of advertising on price is estimated at over 4.1 cents/SSE gallon at this point in time. Thus, the benefits of advertising may be even greater in the supply constrained environment expected in upcoming years.

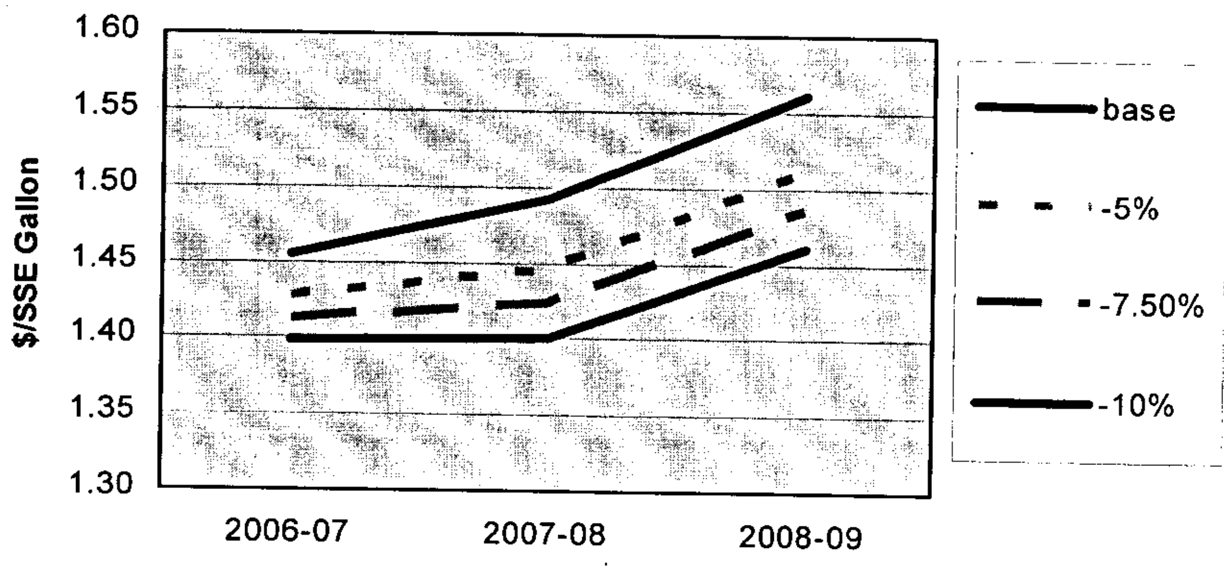
Table 1. Projected Florida Bulk FCOJ FOB Prices for Alternative Reductions in Demand Due to Elimination of Generic Advertising.

	Base Model With Constraints				Base Model Without Constraints	
	Reduction in U.S. Demand					
	0	-5.0%	-7.5%	-10.0%	0	-10.0%
	FL Bulk FCOJ Price ($/sSE gallon)					
2006-07	1.45	1.43	1.41	1.40	1.45	1.40
2007-08	1.49	1.45	1.42	1.40	1.42	1.33
2008-09	1.56	1.51	1.48	1.46	1.44	1.34
2009-10	1.63	1.58	1.56	1.53	1.46	1.36
2010-11	1.71	1.66	1.63	1.61	1.47	1.37
2011-12	1.79	1.74	1.72	1.69	1.47	1.37
2012-13	1.87	1.82	1.80	1.77	1.46	1.37
2013-14	1.94	1.90	1.88	1.85	1.44	1.36
2014-15	2.01	1.97	1.95	1.93	1.42	1.36
2015-16	2.07	2.04	2.02	2.00	1.41	1.35
2016-17	2.13	2.09	2.08	2.06	1.39	1.34
2017-18	2.17	2.14	2.13	2.11	1.37	1.34
2018-19	2.21	2.18	2.17	2.15	1.36	1.33
2019-20	2.24	2.21	2.20	2.19	1.34	1.33
2020-21	2.26	2.24	2.23	2.22	1.34	1.33
2021-22	2.27	2.25	2.24	2.23	1.33	1.33
2022-23	2.28	2.26	2.25	2.24	1.33	1.34
2023-24	2.28	2.27	2.26	2.25	1.34	1.35
2024-25	2.28	2.27	2.26	2.26	1.35	1.36
2025-26	2.28	2.27	2.26	2.26	1.36	1.37
2026-27	2.28	2.27	2.26	2.25	1.38	1.39
2027-28	2.27	2.26	2.26	2.25	1.40	1.40
2028-29	2.27	2.26	2.25	2.25	1.42	1.42
2029-30	2.27	2.25	2.25	2.24	1.44	1.44
2030-31	2.26	2.25	2.25	2.24	1.47	1.46

Figure 1. Florida Bulk FCOJ Price Projections With Versus Without Advertising, Supply Constrained



Florida Bulk FCOJ Price Projections For Alternative Reductions in Demand, Supply Constrainted



References

Brown, M.G. "Advertising Impacts on the Demand for Orange Juice." Staff Report 2003-02. Florida Department of Citrus, Economic and Market Research Department, Gainesville, Fl. 2003.

Brown, M.G. "World Orange-Juice Production and Consumption Trends." Staff Report 2004-6. Florida Department of Citrus, Economic and Market Research Department, Gainesville, Fl. May 2004.

Brown, M.G., and Jonq-Ying Lee. "Health and Nutrition Advertising Impacts on the Demand for Orange Juice in Fifty Metropolitan Regions." Journal of Food Products Marketing 5:3(1999): 31-47.

Brown, M.G., Thomas H. Spreen and Jonq-Ying Lee. "Impacts on U.S. Prices of Reducing Orange Juice Tariffs in Major World Markets." Journal of Food Distribution Research 35:2(2004): 26-33.

Capps, Jr., O.; D.A. Bessler; and G.W. Williams. "Evaluating the Economic Impacts Associated with Advertising Efforts of the Florida Department of Citrus." Prepared for the Advertising Review Committee in Association with the Florida Department of Citrus and Florida Citrus Mutual. College Station, TX: Forecasting and Business Analytics, LLC (FABA).

Florida Agricultural Statistics Service (FASS). Citrus Summary. Various issues, Orlando, FL.

Florida Agricultural Statistics Service. "Commercial Citrus Inventory 2004." Orlando, Florida, 2005.

Florida Citrus Processors Association. *Statistical Summary 2003-04 Season.* Winter Haven, Fl.

Florida Department of Citrus, Economic and Market Research Department. "Florida Citrus Production Trends, 2005-06 Through 2014-15." University of Florida, McCarty Hall, Gainesville, Florida, February 2005, Web Site: www.floridajuice.com.

Food and Agriculture Organization of the United Nations. "Citrus Fruit, Fresh and Processed, Annual Statistics, 2003."Commodities and Trade Division, FAO, Rome, Italy.

McClain, Emily A. "A Monte Carlo Simulation Model of the World Orange Juice Market." Unpublished Ph.D. dissertation, Food and Resource Economics Department, University of Florida, Gainesville, FL, 1989.

Mondragon, Juan Pablo, Thomas H. Spreen, Chris O. Andrew, and Ronald P. Muraro. Oranges of Eastern Mexico: An Economic Analysis of Production and Marketing Channels. Lake Alfred, FL: Florida Science Source, Inc., 1998, 129pp.

Panel of Citrus Economists, appointed by the Florida Citrus Commission. "Generic Promotions of Florida Citrus." Lakeland, Florida, April 2005.

Schmitz, Andrew, James L. Seale, Jr., and Charles B. Moss. "Determinants of Brazil's Ethanol-Sugar Blend Ratios." International Sugar Journal 106(2004):586-96.

Spreen, Thomas H., Ronald Muraro, and Gary F. Fairchild. "The Impact of the North American Free Trade Agreement on U.S. Citrus Producers." American Farm Bureau Federation, Park Ridge, IL. (Reprinted as International Working Paper Series, IW92-3, Food and Resource Economics Department, University of Florida, Gainesville, FL, May 1992, 77pp.)

Spreen, Thomas H., Charlene Brewster, and Mark G. Brown. "The Free Trade Area of the Americas and the World Processed Orange Market." Journal of Agricultural and Applied Economics 35(2003): 107-26.

Spreen, Thomas H.; R. E. Barber, Jr.; M.G. Brown; A.W. Hodges; J.C. Malugen; W.D. Mulkey; R.P. Muraro; R. P. Norberg; M. Rahmani; F.M. Roka; and R.E. Rouse.. "An Economic Assessment of the Prospects for the Florida Citrus Industry." Food and Resource Economics Department, University of Florida (May, 2006). Web Site: http://www.fred.ifas.ufl.edu/economic_assess_flciturus_indus.pdf

United States Department of Agriculture, Foreign Agriculture Service. GAIN Report: BR5026.

Appendix

In this section, relationships between OJ supply, demand and prices in the world are discussed. Let Q(p, t) and q(p, t) be world OJ supply and demand, respectively, where t is time and p is the Florida FOB price for bulk FCOJ. In this model, the Florida FOB price p is used as an approximation of the world price, based on the relatively high correlation between this FOB price and other world OJ prices over time.[3] The variable t is used to indicate changes over time in supply and demand. Supply may change due to growing conditions, diseases such as canker or greening, hurricanes, and use of citrus acreage for alternative uses; while, demand may change due to consumer income growth, advertising and enhanced preferences, among other factors.

In equilibrium, price is at a level such that supply equals demand, i.e,

(1) $Q(p, t) = q(p, t)$.

An important part of the model is how changes in supply and demand impact price. If supply Q grows faster than demand q, price p will tend to decrease and vice versa; if supply and demand change by the same amount, price will tend to remain constant. These price tendencies can be formalized by totally differentiating equation (1) and solving for the price change dp (d before a variable is used to indicate a change in that variable; in this case, $dp_t = p_t - p_{t-1}$, where time subscripts have been added), i.e.,

(2) $(\partial Q/\partial p)dp + (\partial Q/\partial t)dt = (\partial q/\partial p)dp + (\partial q/\partial t)dt$

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[3] The market for OJ is comprised of a number of differentiated products. OJ is differentiated by product form (FCOJ and NFC) and attributes including ratio, color and viscousity. In principle, separate demands for each differentiated product could be specified as a function of the product's (own) price and the (cross) prices of all the other differentiated OJ products, as well as other variables such as prices of other goods, consumer income and advertising. However, given these OJ products are close substitutes, their prices tend to be highly correlated, and estimation of separate own and cross-price parameters is problematic. Thus, given the high correlation of prices, OJ is modeled as a single product with one price in this analysis.

or, rearranging terms,

(3) $dp = [(\partial q/\partial t)dt - (\partial Q/\partial t)dt] / (\partial Q/\partial p - \partial q/\partial p)$.

The supply slope is positive or $\partial Q/\partial p > 0$; the demand slope is negative or $\partial q/\partial p < 0$; thus the denominator of equation (3) is positive or $(\partial Q/\partial p - \partial q/\partial p) > 0$. If demand and/or supply grows, contracts or is unchanged, the terms $(\partial q/\partial t)dt$ and/or $(\partial Q/\partial t)dt$ would be positive, negative or zero, respectively. The strengths of these supply and demand changes determine the price change. For example, if there is no change in demand, so that $(\partial q/\partial t)dt = 0$, and supply grows or $(\partial Q/\partial t)dt > 0$, then price will fall, $dp < 0$, according to equation (3).

OJ Supply

World OJ supply in a given year is specified as

(a) beginning OJ inventories in Florida (Florida Citrus Processors Association or FCPA) plus

(b) beginning OJ inventories in Brazil (USDA-FAS) plus

(c) Florida OJ production plus

(d) other U.S. OJ production plus

(e) Brazil OJ production plus

(f) rest-of-the-world (ROW) OJ production.

Beginning inventories are predetermined based on previous season supply and demand. Florida OJ production is based on the Florida orange crop which is determined based on Florida bearing orange acreage times boxes of fruit per acre, by age (Florida Agricultural Statistics Service or FASS). The part of the model for Florida orange production is an extension of a model used by the FDOC to project production; see "Florida Citrus Production Trends, 2005-06 Through 2014-15," for discussion of this model. Acreage, yield and orange production estimates are disaggregated by early and midseason oranges and Valencia oranges. The initial acreage, upon which the future production projections depend, is based on the bearing trees reported by FASS for the 2005-06 season. The bearing acreage in 2006-07 is the surviving 2005-06 bearing acreage plus surviving acreage planted in 2003 (the maturation of non-bearing two year old trees to bearing three year old trees). Acreage in subsequent years is similarly, recursively determined. Acreage losses due to citrus diseases, hurricanes and development enter the model through assumed loss rates used in projecting the acreage forward through time. (Cost increases due to these factors also enter the model through planting equations, as subsequently discussed.) Additionally, yields per acre are dependent on assumed acreage infected with canker. For infected acreage, yields for early and midseason oranges and Valencia oranges are assumed to decrease by 10% and 5%, respectively. Yields are also adjusted for the possibility of hurricane losses. Average yields from 1993-94 through 2003-04 are used to represent yields in non-hurricane seasons, while yields in the hurricane-impacted season of 2004-05 are used to represent yields in future hurricane-impacted seasons. For example, if the probability of a future hurricane is set at 10%, the future yields used in the simulation are weighted averages, calculated as 90% of the non-hurricane yields plus 10% of the hurricane yields.

Florida orange planting equations for early and midseason oranges and Valencia oranges were estimated and used in the model to determine acres planted. The planting equations link prices to future supply. The general planting specification for both varieties of oranges used is

(4) $n_t = a+b*p^e_{f,t}$

where n_t is the number of acres planted, $p^e_{f,t}$ is the expected futures price for FCOJ at time t, and a and b are estimated (positive) parameters. An adaptive expectations specification was used to model the expected price: $p^e_{f,t} = \lambda * p_{f,t-1} + (1-\lambda) * p^e_{f,t-1}$, where $p_{f,t-1}$ is the actual futures price at time t-1, deflated by the consumer price index (CPI), and λ is a parameter between zero and one, estimated at .73 here.

The impacts on planting levels due to cost changes such as the increase in the cost of citrus land related to the demand for land for development are considered by adjusting the intercept in equation (4). It is assumed that the expected delivered-in price differs from the expected futures price by a constant, i.e., $p^e_d = a_1 + p^e_f$, where p^e_d is the expected delivered-in price and a_1 is the constant. An expected net grower price is specified as $p^e_n = p^e_d - c$, where c represents costs. Hence, through substitution, $p^e_n = a_1 + p^e_f - c$. Using this result, the planting equation can also be written as

$$n_t = a_0 + b * p^e_{n,t}$$

or

$$n_t = a_0 + b * (a_1 + p^e_{f,t} - c_t)$$

or

$$n_t = a + b * p^e_{f,t},$$

where

$$a = (a_0 + b * a_1 - b * c_t).$$

The above result implies that if costs change by dc, then the intercept a changes by the amount -b*dc; thus, given b is positive, an increase in costs results in a decline in the planting level of b*dc. Equation (4) is incorporated into the model in difference form:

$$(n_t - n_{t-1}) = b * (p^e_{f,t} - p^e_{f,t-1}) - b * (c_t - c_{t-1})$$

or

$$n_t = n_{t-1} + b * (p^e_{f,t} - p^e_{f,t-1}) - b * (c_t - c_{t-1}).$$

Processed orange utilization is estimated as boxes of Florida oranges produced, as determined above, minus an assumed fresh utilization level (certified and noncertified) of 9 million boxes. An average juice yield per box is then applied to the processed orange utilization estimate to obtain OJ production. Additionally, OJ production from specialty citrus production is estimated by multiplying an average specialty processed utilization rate times specialty citrus production times the average juice yield. Specialty citrus production is assumed to follow the same trend as orange production over the projection period.

Other U.S. OJ production is set at the average level over the five year period from 2000-01 through 2004-05, while ROW OJ production is based on data reported in "Citrus Fruit, Processed and Fresh, Annual Statistics 2003," CCP:CI/ST/2003, by the Food and Agricultural Organization (FAO) of the United Nations. In the model, ROW OJ production is assumed to grow by 1% annually.

Brazil's OJ production is estimated similarly as Florida's. Sao Paulo's bearing and non-bearing trees (USDA) are projected forward based on an assumed tree loss rate and planting equation. Sao Paulo orange production is then estimated as the projected bearing trees times an average yield per tree. Sao Paulo processed orange boxes are estimated as production minus an assumed fresh utilization level held constant over the projection period. Sao Paulo OJ production is then estimated as processed orange boxes times an average juice yield. OJ production in Brazil outside of Sao Paulo is estimated as constant, based on recent levels.

The planting equation for Sao Paulo is

(5) $n_{b,t} = e + f^{*}p^{e}_{fs,t}$

where $n_{b,t}$ is the number of trees planted, $p^e_{fs,t}$ is an expected price ratio, the FCOJ futures price divided by the Brazil sugar price, and e and f are estimated parameters. As in the Florida planting equation above, an adaptive expectations specification was used to model the expected price variable.

Growing sugar cane is an important alternative land use for citrus acreage in Brazil. About half of Brazil's sugar cane is used in producing ethanol. Recent energy price increases have resulted in increases in demand for ethanol, which, in turn, has resulted in increases in ethanol and sugar prices, making sugar cane production more profitable. Based on industry reports, 14 new ethanol refineries will come into operation in Brazil in the upcoming year, in addition to about 50 refineries presently being operated there. The New York futures price for sugar is about $.08 per pound (1/24/2006) or about 80% greater than the 2005 level.

Based on estimates of the above supply components, season-to-season changes in aggregate OJ supply, $(\partial Q/\partial t)dt$ in equation (3), can the be determined. To obtain an estimate of the price change (dp), estimates are needed of the change in world demand with prices constant or $(\partial q/\partial t)dt$, and the world demand slope or $\partial q/\partial p$.

For season-to-season changes, the supply slope, $\partial Q/\partial p$, is assumed to be zero; in the long-run this slope is positive based on planting equations (4) and (5). It takes about three years for a newly planted tree to produce oranges for commercial use. Thus, even though the current price, as well as past prices, impact current planting levels in the model, because of the lag between the planting year and the year in which the newly planted trees bear fruit, the current price does not impact current production in the model. Thus, based on equation (3), the season-to-season change in the price of OJ is calculated as

(6) $$dp = [(\partial Q/\partial t)dt - (\partial q/\partial t)dt] / (\partial q/\partial p).$$

The numerator of this equation indicates excess supply, excess demand or neutral supply and demand shifts, when its sign is positive, negative or zero, respectively. The inverse of the term $\partial q/\partial p$ or $\partial p/\partial q$ transforms the excess supply or demand into a price change.

OJ Demand

Annual demand growth rates are assumed to determine the volume (gallon) change in world demand, $(\partial q/\partial t)dt$. In the model, world demand is disaggregated into five components. Each of these components, along with a baseline demand growth assumption, is shown below.

U.S. OJ consumption: 1%

U.S. OJ exports: 1%

ROW consumption: 2%

Florida ending OJ inventory: 1%

Brazil ending OJ inventory: 1%

For each component, the growth rate times the previous period demand component level yields an estimate of the volume growth in demand for the component. As mentioned above, three scenarios for generic advertising were considered: U.S. demand additionally increases by 5% , 7.5% and10%. The sum of the annual volume growth and the generic advertising shift provides an estimate of $(\partial q/\partial t)dt$.

The last term needed to determine the price change, equation (6), is the world demand slope $\partial q/\partial p$. This term is calculated as the sum of the FOB price slopes for the five world OJ demand components above. World demand can be written as

(7) $q = \sum_{i = 1 \text{ to } 5} q_i\,(p_i, t)$,

where i stands for a component; and $p_i = p + m_i$ or the FOB price for component i, with m_i being the margin between the Florida FOB price p and the FOB price for component i. Differentiating world demand with respect to price p results in $\partial q/\partial p = \sum_{i=1 \text{ to } 5} \partial q_i/\partial p_i$. The component quantity-price slopes ($\partial q_i/\partial p_i$) are based on previous research ("Generic Promotions of Florida Citrus," prepared by a Panel of Economists, appointed by the Florida Citrus Commission, Lakeland, Florida; "The Free Trade Area of the Americas and the Market for Processed Orange Products," by T. Spreen, C. Brewster and M. Brown; and "Impacts on U.S. prices of Reducing Orange Juice Tariffs in World Markets," by M. Brown, T. Spreen and J. Lee) and recent preliminary demand estimates. The estimated FOB price elasticities for U.S. OJ consumption, U.S. OJ exports and ROW OJ demand are -.34, -.66 and -.40, respectively. The Florida and Brazil inventory elasticities were estimated at -.56 and -.88, respectively. The five elasticities, defined by $\epsilon_i = (\partial q_i/\partial p_i)(p_i/q_i)$, were transformed to quantity-price slopes based on the relationship $\epsilon_i * (q_i/p_i) = (\partial q_i/\partial p_i)$.

The price based on equation (6) is such that world demand exactly equals world supply. The demand level for each component is calculated based on the differential of the component's demand, i.e., $dq_i = (\partial q_i/\partial p_i)dp + (\partial q_i/\partial t)dt$, or $q_{i,t} = q_{i,t-1} + (\partial q_i/\partial p_i)dp + (\partial q_i/\partial t)dt$. That is, the component demand slope is multiplied by the price change from equation (6) and the result is added to the product of the assumed volume growth rate for the component and the previous component demand volume.