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SNOWFALL DEPTH AND THE DEMAND FOR ORANGE JUICE

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Snowfall Depth and the Demand for Orange Juice

The purpose of this study is to investigate the relationship between snowfall depth and the demand for orange juice. In this study, we assume that the per capita demand for orange juice is influenced by its own price, per capital food expenditure, seasonality, time trend in the market, retail promotional activities, and snowfall depth. Whether the last influencing factor, snowfall depth, has any impact on orange juice consumption is unknown. Based on an old study conducted in Campbell Soup Inc. the current Florida Department of Citrus' Executive Director Mr. Santangelo suggested that snowfall depth could be an influencing factor of orange juice demand. The Campbell Soup study found that the demand for Campbell soup was influenced by the amount of snowfall received in the market area sutdied. Mr. Santangelo indicated that the same argument should be applicable to the demand for orange juice. Mr. Santangelo explained that people live in snowfall areas may increase their orange juice consumption if they believe the consumption of orange juice reduces cold symptoms during winter months. Snowfall means cold winter days and cold winter days mean people need to drink more orange juice to increase their bodies' defense to cold related illnesses.

Twenty market areas were studies. These market areas are the top-ten and bottom-ten orange juice consumption market areas. The top-ten orange juice consumption markets are Boston, Baltimore, Miami, Albany, Des Moines, Philadelphia, Hartford/New Haven, Buffalo/Rochester, Syracuse, and Tampa. The bottom-ten orange juice consumption markets are Little Rock, Seattle, Memphis, Kansas City, Phoenix, Dallas, San Diego, Oklahoma City/Tulsa, Sacramento, and Los Angeles.

Data used in this study came from two sources. Orange juice consumption information (quantities of orange juice consumed, orange juice retail prices, retail promotional activities in terms of percent of ACV -- A/B advertising, coupon advertising, and displays) for these twenty markets was provided by ACNielsen. Snowfall information was gathered from selected issues of *Climatological Data* published by the National Ocean and Atmospheric Administration. Generally, there are more than one weather station in each market area. Some weather stations reported snowfall depth information during the study period and some stations discontinued their snowfall reporting in the later part of the study period. In order to obtain a consistent series of snowfall statistics for each market area, the stations located at the airports were chosen for this study. When the complete snowfall information was not available at the airport weather station, a nearby weather station with complete snowfall information was chosen. The weather stations used in the study for the respective market areas are listed in Table 1.

The study period covers the weeks from 12/09/95 through 10/30/99, i.e., a 208-week period. Daily snowfall information for each market area was aggregated into weekly totals for the corresponding ACNielsen reporting weeks. Sample averages of all variables used in this study are presented in Table 2. As shown in Table 2, the weekly average per capita orange juice consumption for the top-ten markets was 9.54 ounces and 5.87 ounces for the bottom-ten markets. Retail prices were generally higher in the bottom-ten markets than in the top-ten markets. This is probably because most bottom-ten markets are located in the Western states of the U.S. Per capita food expenditures were about the same for the top-ten and bottom-ten

markets. Retail promotional activities show different patterns for the top-ten and bottom-ten markets. In the top-ten markets, A/B ads were present in more than 80% of the ACV, displays were present in 25% of the ACV, and coupon ads were present only in 5% of the ACV. In the bottom-ten markets, A/B ads were present in 73% of the ACV, displays were present in 29% of the ACV, and coupon ads were present only in 14% of the ACV. In general, top-ten markets received more snowfall than the bottom markets. The weekly average snowfall per week in the top-ten markets was 0.71 inch, while the bottom-ten markets received only 0.06 inch per week.

Due to the differences in prices, per capita food expenditure, retail promotional activities, and the amount of snowfall received among these twenty markets, multiple-regression analysis was deemed necessary to sort out the influence of each factor on orange juice consumption. Formally, the demand relationship can be expressed as

$$(1) \qquad q_{it} = \beta_0 + \beta_1 p_{it} + \beta_2 s + \beta_3 A/B_{it} + \beta_4 Coup_{it} + \beta_5 Disp_{it} + \beta_6 Snow_{it} + \beta_7 t + \varepsilon_{it}$$

where subscript *t* represents week, subscript *i* represents market area, q is the per capital orange juice consumption, p is the retail orange juice price, s is a variable for seasonlity, A/B is the A/B advertising in percent of ACV, Coup is the coupon advertising in percent ACV, Disp is the display in percent of ACV, and Snow is the amount of snowfall in inches, ε is the disturbance term, and βs are the demand parameters to be estimated.

In order to adjust for seasonality, the fifty-second differences were used in (1). The resulting model can be written as

$$(2) \qquad q_{it} - q_{it-52} = \beta_1(p_{it} - p_{it-52}) + \beta_3(A/B_{it} - A/B_{it-52}) + \beta_4(Coup_{it} - Coup_{it-52}) + \beta_5(Disp_{it} - Disp_{it-52}) + \beta_6(Snow_{it} - Snow_{it-52}) + \beta_7 + (\varepsilon_{it} - \varepsilon_{it-52}).$$

Note that in (2), the new intercept, β_7, represents the time trend parameter. Since the disturbance terms among the twenty market areas studied could be correlated, the seemingly unrelated regression technique was used to estimate the demand relationship shown in (2). Results are presented in Tables 3 and 4.

Results in Tables 3 and 4 show that all own-price parameters are statistically different from zero and negative, indicating that when price increases, the demand for orange juice decreases. This result is consistent with our expectations. Most income parameters are significant and positive, showing that when food expenditure increases, orange juice consumption also increases. Of the 60 parameter estimates for retail promotional activities, i.e., A/B ads, coupon ads, and displays, 22 are statistically different from zero, or 37% of the promotional activity parameters. There are more significant promotional activity parameters in the bottom-ten market demand equations than in the top-ten market demand equations. Results show that coupon ads and displays in the bottom-ten markets helped increase orange juice consumption.

Of the twenty markets studied, 14 of them had snowfall during the study period. Parameter estimates for the snowfall variable in these markets' demand equations are mostly not

different from zero. Of the 14markets, only three were statistically different from zero -- one in the top-ten market group and two in the bottom-ten market group. In addition, in markets that received the most snowfall during the study period, such as Albany, Syracuse, Buffalo/Rochester, and Boston, the amount of snowfall showed no impact on orange juice consumption. Where snowfall parameters were statistically different from zero and positive: Hartford/New Haven, Seattle, and Memphis; the amount of snowfall was relatively small. One may argue that the amount of snowfall had a positive impact on the orange juice consumption in these markets that seldom had snowfall. Or, based on the fact that only three out of 14 markets show positive snow impacts on orange juice consumption and that these three markets seldom had snowfall, one may consider the result could be spurious.

Table 5 shows the price and income elasticities estimated at sample means. Results show that, in general, the demand for orange juice in the top-ten markets was less price elastic than the demand in the bottom-ten markets. The average price elasticity estimate for the top-ten and bottom-ten markets are -0.95 and -1.06, respectively. Results also show that the demand for orange juice in the top-ten markets is less income elastic than the demand in the bottom-ten markets. Note that the income elasticity estimate for Los Angeles market area is 7.37. In our opinion, this estimate is incorrect, therefore, it was not included in the calculation of the average income elasticity for the bottom-ten markets. Results show that the average income elasticity for the top-ten and bottom-ten markets are 0.56 and 0.62, respectively. In other words, when food expenditure is increased by one percent, the people in top-ten markets would increase their orange juice consumption by 0.56% but the people in the bottom-ten markets would increase their orange juice consumption by 0.62%.

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Table 1. Market area and weather station location

Market	State	County	Station ID	Station Name
Boston	MA	Windham CN	9388	W. Thompson Lake
Baltimore	MD	Anne Arundel MD	0465	Baltimore WSO AP
Miami	FL			
Albany	NY	Albany NY	0042	Albany WSFO AP
Des Moines	IO	Polk IO	0241	Ankeny
Philadelphia	PA	Montgomery PA	6889	Philadelphia WSCMO AP
Hartford/New Haven	CN	Hartford CN	3456	Hartford WSO Airport
Buffalo/Rochester	NY	Monroe NY	7167	Rochester WSO AP
Syracuse	NY	Onondaga NY	8383	Syracuse WSO AP
Tampa	FL			
Little Rock	AR	Pulaski AR	4248	LR CWOS AP
Seattle	WA	King WA	7473	Seattle Tacoma AP
Memphis	TN	Shelby TN	5956	Memphis WSFO
Kansas City	KS	Platte MO	4358	Kansas City WSMO AP
Phoenix	AZ	Maricopa AZ	6481	Phoenix AP
Dallas	TX	Dallas TX	3285	Ft. Worth WSFO
San Diego	CA	San Diego CA	7740	San Diego WSO AP
Oklahoma City/Tulsa	OK	Oklahoma OK	6661	Oklahoma City AP
Sacramento	CA	Sacramento CA	7630	Sacramento FAA AP
Los Angeles	CA	Los Angeles CA	5114	Los Angeles WSO AP

Table 2. Sample mean statistics -- 12/09/95 through 10/30/99

Market	Consumption (oz/week)	Price ($/gallon)	Food Exp. ($1,000)	A/B Ads (% ACV)	Coupon Ads (% ACV)	Displays (% ACV)	Snow Fall (in/week)
				Top-ten Markets			
Boston	11.22	3.91	1.606	84.7	2.6	35.4	0.9069
Baltimore	9.48	4.30	1.510	80.3	8.1	38.3	0.4382
Miami	10.42	3.72	1.553	80.2	4.0	3.9	0.0
Albany	9.07	3.65	1.712	90.6	1.7	17.7	1.1623
Des Moines	9.49	3.28	1.685	50.4	16.7	25.9	0.3451
Philadelphia	8.90	4.03	1.540	86.1	4.5	17.9	0.1230
Hartford/New Haven	9.62	3.88	1.584	89.5	3.9	24.3	0.3426
Buffalo/Rochester	9.65	3.83	1.607	90.0	4.0	48.4	1.7520
Syracuse	8.49	3.77	1.504	81.1	3.8	31.1	2.0343
Tampa	9.07	3.63	1.666	72.2	2.5	10.2	0.0
Average	9.54	3.80	1.597	80.5	5.2	25.3	0.7104
				Bottom-ten Markets			
Little Rock	5.49	3.47	1.484	49.1	1.1	25.6	0.0294
Seattle	6.80	3.87	1.812	65.8	27.2	30.5	0.1098
Menphis	5.66	3.54	1.466	69.3	4.0	38.0	0.0250
Kansas City	5.75	3.58	1.413	65.0	4.6	37.8	0.3583
Phoenix	6.61	4.10	1.637	83.2	24.5	30.7	0.0
Dallas	6.18	3.95	1.574	76.5	8.1	31.3	0.0167
San Diego	5.62	4.89	1.396	90.2	19.7	25.0	0.0
Oklahoma City/Tulsa	5.38	3.75	1.580	64.2	2.0	29.7	0.0750
Sacramento	5.73	4.25	1.563	79.3	27.8	14.4	0.0
Los Angeles	5.49	4.96	1.306	88.3	20.6	22.2	0.0
Average	5.87	4.04	1.523	73.1	14.0	28.5	0.0614

Table 3. Demand parameter estimates -- top-ten markets, 12/09/95 through 10/30/99

Market	Time Trend	Price	Income	A/B Ads	Coupon Ads	Displays	Snow Fall
Boston	0.2962*	-1.7087*	-0.5882	0.0024	-0.0060	0.0035	0.0033
	(0.1028)	(0.2546)	(1.2772)	(0.0034)	(0.0071)	(0.0074)	(0.0131)
Baltimore	0.7581*	-2.8360*	7.4348*	-0.0028	0.0004	-0.0023	0.0066
	(0.0977)	(0.2441)	(3.9720)	(0.0047)	(0.0079)	(0.0050)	(0.0259)
Miami	0.2200*	-1.0180*	-6.0091	-0.0015	-0.0001	0.0114*	
	(0.0816)	(0.2027)	(6.7220)	(0.0014)	(0.0042)	(0.0076)	
Albany	0.3736*	-2.5681*	8.7514*	0.0069*	-0.0054	0.0092*	-0.0024
	(0.0620)	(0.1976)	(1.3378)	(0.0036)	(0.0088)	(0.0042)	(0.0126)
Des Moines	0.3947*	-2.2286*	-2.1528	0.0025	-0.0033*	-0.0113*	0.0203
	(0.0607)	(0.1385)	(1.5073)	(0.0018)	(0.0017)	(0.0030)	(0.0259)
Philadelphia	0.5440*	-2.2670*	4.8213	-0.0140*	-0.0108*	-0.0041	0.0309
	(0.0699)	(0.2310)	(3.4345)*	(0.0037)	(0.0055)	(0.0078)	(0.0514)
Hartford/New Haven	0.1404	-2.3194*	4.6444	0.0019	0.0076	0.0175*	0.0888*
	(0.1270)	(0.2189)	(2.0433)	(0.0043)	(0.0062)	(0.0055)	(0.0314)
Buffalo/Rochester	0.4158*	-3.4284*	7.8051*	-0.0032	-0.0058	0.0156*	-0.0171
	(0.1500)	(0.2781)	(2.2586)	(0.0091)	(0.0064)	(0.0067)	(0.0155)
Syracuse	0.6051*	-2.8059*	3.2046*	0.0026	0.0081	0.0047	-0.0072
	(0.0761)	(0.1673)	(1.2694)	(0.0024)	(0.0063)	(0.0035)	(0.0077)
Tampa	0.4083*	-2.2370*	3.5354*	-0.0015	0.0007	0.0037	
	(0.0396)	(0.1127)	(1.0189)	(0.0014)	(0.0029)	(0.0043)	

*Statistically different from zero at $\alpha = .01$ level, numbers in parentheses are standard error of estimates

Table 4. Demand parameter estimates -- bottom-ten markets, 12/09/95 through 10/30/99

Market	Time Trend	Price	Income	A/B Ads	Coupon Ads	Displays	Snow Fall
Little Rock	0.0331	-1.7891*	1.8314*	-0.0015	-0.0006	-0.0070*	0.0699
	(0.0649)	(0.1210)	(0.8816)	(0.0017)	(0.0098)	(0.0024)	(0.0732)
Seattle	-0.0052	-1.6275*	3.9034*	0.0071*	0.0010	0.0101*	0.1098*
	(0.0692)	(0.1259)	(0.6967)	(0.0021)	(0.0022)	(0.0035)	(0.0269)
Menphis	0.1042*	-2.2470*	1.8798*	-0.0003	0.0124*	-0.0023	0.3158*
	(0.0419)	(0.1297)	(0.5275)	(0.0013)	(0.0034)	(0.0030)	(0.0751)
Kansas City	0.2925*	-2.2266*	7.1488*	0.0025	0.0098*	0.0009	0.0201
	(0.0487)	(0.1255)	(1.3738)	(0.0020)	(0.0047)	(0.0035)	(0.0214)
Phoenix	0.3799*	-2.1762*	2.4431*	0.0010	0.0065*	-0.0014	
	(0.0617)	(0.1097)	(0.9306)	(0.0024)	(0.0018)	(0.0038)	
Dallas	0.0194	-1.4342*	2.5201*	-0.0010	-0.0001	0.0053*	-0.0172
	(0.0350)	(0.0994)	(0.4773)	(0.0014)	(0.0018)	(0.0018)	(0.1322)
San Diego	0.2225*	-1.0906*	0.6236*	0.0028*	0.0030*	0.0008	
	(0.0441)	(0.0672)	(0.3178)	(0.0015)	(0.0011)	(0.0017)	
Oklahoma City/Tulsa	0.0083	-1.3638*	1.0921*	-0.0019	0.0018	-0.0013	0.0530
	(0.0584)	(0.1432)	(0.5715)	(0.0022)	(0.0078)	(0.0026)	(0.0508)
Sacramento	0.1765*	-0.9236*	0.3058	0.0060*	0.0037*	0.0140*	
	(0.0584)	(0.0941)	(0.4841)	(0.0022)	(0.0020)	(0.0047)	
Los Angeles	0.1095*	-0.9378*	30.9723*	0.0007	-0.0012	0.0043*	
	(0.0363)	(0.0594)	(4.0960)	(0.0017)	(0.0012)	(0.0020)	

*Statistically different from zero at $\alpha = .01$ level, numbers in parentheses are standard error of estimates

Table 5. Demand elasticity estimates

	Elasticity Estimate	
	Price	Income
Top-ten Markets		
Boston	-0.5948	-0.0842
Baltimore	-1.2848	1.1841
Miami	-0.3633	-0.8959
Albany	-1.0336	1.6513
Des Moines	-0.7706	-0.3824
Philadelphia	-1.0265	0.8336
Hartford/New Haven	-0.9344	0.7642
Buffalo/Rochester	-1.3615	1.3002
Syracuse	-1.2451	0.5681
Tampa	-0.8965	0.6496
Average	-0.9511	0.5589
Bottom-ten Markets		
Little Rock	-1.1328	0.4953
Seattle	-0.9273	1.0410
Menphis	-1.4031	0.4865
Kansas City	-1.3887	1.7575
Phoenix	-1.3494	0.6054
Dallas	-0.9161	0.6418
San Diego	-0.9489	0.1549
Oklahoma City/Tulsa	-0.9507	0.3210
Sacramento	-0.6857	0.0835
Los Angeles	-0.8470	7.3697
Average	-1.0550	0.6208