IMPORTANCE OF UNDERSTANDING CONSUMPTION DYNAMICS IN MARKET RECOVERY PERIODS

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Periods of reduced supplies due to exogenous shocks and subsequent high price levels have occurred for many agricultural commodities in the past decade. Consumers' adjustments to these events depend on the magnitude of the shocks and characteristics of the commodity. Understanding consumers' responses to these events requires recognition of rigidities that result in delays in consumer responses to prices.

Recognition of rigidities in consumption relationships by using dynamic stock and flow adjustment models was popularized by Houthakker and Taylor [2]. The models recognize the role of inventories and habits resulting from previous purchase patterns in determining current consumption decisions. Though Houthakker and Taylor recognize that "each commodity has some forces making for inventory adjustment and some making for habit formation, and the single stock coefficient represents an amalgam of those opposing tendencies" [2, p. 164] it is Sexauer [6] who incorporates both effects into the theoretical construct. Sexauer's [6] model restatement and empirical analyses also recognize that the degree to which habit or inventory effects dominate depends on the length of the data period observed. Shorter data periods are more likely to result in the observance of inventory-type effects.

Both the Houthakker and Taylor [2] and Sexauer [6] analyses are performed at levels of aggregation that are of little use when exogenous shocks are specific to particular forms of individual commodities. Neither study recognizes that changes in measured aggregate consumption relationships reflect the composite of changes in number of buyers and changes in quantity purchased per buyer.

The objectives of this article are to:

1. Demonstrate, using frozen concentrated orange juice (FCOJ) and chilled orange juice (COJ) as examples, the importance of product definition within a commodity group when reaching conclusions about inventory or habit effect dominance.
2. Show the importance of identifying the extent to which the change in consumption is due to changes in number of buyers or purchases per buyer when attempting to regain sales levels.

The next section presents a restatement of the flow adjustment model and following sections describe estimation methods, empirical results for processed orange juice products, and the implications for orange products after a freeze period.

CONCEPTUAL MODEL

The model adopted in this analysis is the dynamic flow adjustment originally published by Houthakker and Taylor [2] and used by Houthakker, Verleger, and Sheehan [3].

The basic hypothesis is a logarithmic adjustment process in which the logarithm of the ratio of purchases this period to last period is proportional to the logarithm of the ratio of fully adjusted level of purchases for this period to the actual level last period. In logarithmic form, the model is:

$$\text{(1)} \qquad \ln q_t - \ln q_{t-1} = \phi(\ln q_t^* - \ln q_{t-1})$$

where

q_t = actual consumption in period t
q_t^* = fully adjusted level of consumption in period t and
Φ = the adjustment parameter and is greater than zero.

The long-run or fully adjusted level of consumption (q_t^*) refers to the level of consumption after inventory effects or habit effects

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have dissipated.[1] That is, again in double logarithmic form:

$$(2) \quad \ln q_t^* = \beta_0 + \beta_1 \ln P_{1t} + \sum_{j=2}^{J} \beta_j \ln P_{jt} + \delta_1 \ln I_t + \delta_2 S_t + e_t$$

where

q_t^* = fully adjusted per capita quantity of FCOJ purchased in month t
P_{1t} = average retail price paid per unit of FCOJ in month t deflated by the consumer price index
P_{jt} = average price paid per unit of jth (j=2, . . . , J) products that are substitutes, J-1 in number, for FCOJ (deflated by the consumer price index)
I_t = per capita disposable income in month t
S_t = seasonal demand shifter for FCOJ in month t
e_t = error term
β_0 = intercept
β_1 = long-run own-price coefficient for FCOJ
β_j = long-run cross-price coefficients for substitute products and
δ_1, δ_2 = long-run coefficients for income and seasonality.

Equation 1 can be used to eliminate the unobservable q_t^* in equation 2 to yield the following estimatable equation.

$$(3) \quad \ln q_t = \beta_0 + (1-\phi)\ln q_{(t-1)} + \phi\beta_1 \ln P_{1t} + \sum_{j=2}^{J} \phi\beta_j \ln P_{jt} + \phi\delta_1 \ln I_t + \phi\delta_2 S_t + e_t$$

where $\phi\beta_1$, $\phi\beta_j$ represent short-run own-price and cross-price coefficients for FCOJ. The long-run demand coefficients are then estimated as $\widehat{\phi\beta_1}/\hat{\phi}$ and $\widehat{\phi\beta_j}/\hat{\phi}$ where $\hat{\phi}$, the adjustment coefficient, can be calculated from the parameter estimated for $\ln q_{(t-1)}$.

The estimate of ϕ indicates the habit or inventory effect dominance for FCOJ. That is:

if $0<\phi<1$, the $\frac{\partial q_t}{\partial q_{t-1}}>0$ and habit effects dominate inventory effects for FCOJ

if $\phi = 1$, then $q_t \neq f(q_{t-1})$, habit and inventory effects balance out, and $q_t^* = q_t$ from equation 1 and adjustment is immediate to the fully adjusted level

if $2>\phi>1$, then $\frac{\partial q_t}{\partial q_{t-1}}$ 0, inventory effects dominate habit effects, and q_t oscillates around and converges toward q_t^*

if $\phi>2$, then $\frac{\partial q_t}{\partial q_{t-1}}<-1$, inventory effects dominate, and q_t oscillates around and diverges from q_t^*.

Myers [4, p. 34] and Thraen, Hammond, and Baxton [7] have recognized that aggregate changes in consumption can be decomposed into a change in purchases per household (PH_t) and a change in proportion of families buying (FB_t). To identify whether the source of the habit or inventory effects is most related to rigidities in percentage of families buying or to rigidities in ounces purchased per buying household, two additional models are estimated.[2] The two additional models follow the same development as equation 3 except that the logarithm of current and lagged percentage of families buying FCOJ (FB_t) and the logarithm of current and lagged ounces of FCOJ purchased per buying household (PH_t) are substituted for current and lagged per capita purchases variables. These two equations allow identification of the nature of rigidities in percentage of families buying (FB_t) and ounces purchased per household (PH_t). From a marketing standpoint, it is important to know whether a price change causes families to decrease their level of purchases or to stop purchases completely. If inventory-type dominance is the measured effect, the rigidity coefficient $(1-\phi)$ in the percentage of families buying equation would be interpreted as indicating that some consumers enter and purchase, and then exit and do not purchase. Three similar models are estimated for chilled orange juice (COJ).

A Priori expectations as to the magnitude of ϕ for a particular product are difficult to develop. Certainly, for some food products that cannot be stored longer than the observation period it would be difficult to argue that the products are kept in inventory by consumers. COJ is a product in this category. However, FCOJ can be stored in its frozen form for much longer than the monthly observation period. Thus, though it would be logical to hypothesize that COJ would exhibit habit effects, there is no *a priori* reason to hypothesize either habit or inventory dominance for FCOJ when monthly data periods are used. The habit-type dominance would be more likely if the observation period were longer than a month.

[1] It could perhaps be argued that the fully adjusted level represents the expected level of purchases given the assumptions of the neoclassical model.

[2] Decomposition of the short-run and long-run or fully adjusted elasticities into component elasticities for percentage of households buying (FB_t) and purchases per buying household (PH_t) follows directly from Myers [5]. That is q_t^* elasticities can be decomposed into portions due to FB_t^* and PH_t^* whereas q_t elasticities can be decomposed into FB_t and PH_t where FB_t^* and PH_t^* are fully adjusted or long-run percentage of households buying and purchases per buying household, respectively.

ESTIMATION

All of the ordinary least squares assumptions are not likely to hold for equation 2. First, as with any monthly time series, e_t are potentially serially correlated. If serial correlation is present the error term for each equation is also likely to be correlated with the lagged dependent variable. Durbin h-statistics calculated from ordinary least squares residuals indicate the presence of first order serial correlation in all six of the equations. Therefore, the parameters for the six equations were estimated by using the procedure suggested by Fuller [1, p. 435]. The first step in the estimation involves regressing the lagged dependent

TABLE 1. FCOJ AND COJ DYNAMIC, FLOW, ADJUSTMENT DEMAND RELATIONSHIPS

Independent variable[b]	Symbol	Dependent variable[a]: Per capita consumption FCOJ q_t	Per capita consumption COJ q_t	Percent of families buying FCOJ FB_t	Percent of families buying COJ FB_t	Purchases per buying household FCOJ PH_t	Purchases per buying household COJ PH_t
Constant	C	4.1914	-16.1602	7.1319	-14.9786	1.0289	1.3156
		(2.6122)	(5.9061)	(2.6952)	(6.4198)	(1.8218)	(2.5135)
FCOJ price	P_1	-1.4385	-.0633	-.8048	-.0168	-.5906	.0556
		(.1437)	(.1546)	(.1773)	(.1559)	(.0797)	(.1162)
COJ price	P_2	.2267	-.4300	.1938	-.2893	.2609	-.2648
		(.1225)	(.2353)	(.1252)	(.1743)	(.0819)	(.1652)
CSSOJ price	P_3	-.2036	.1948	.0391	.0463	.1469	.1918
		(.1104)	(.1845)	(.1229)	(.1746)	(.0760)	(.1320)
FCOD price	P_4	.0650	.1116	.0913	.0693	-.0359	.0059
		(.0813)	(.1157)	(.0743)	(.1034)	(.0541)	(.0704)
COD price	P_5	.4581	-.0211	.1056	-.0483	.1826	.0372
		(.1015)	(.1193)	(.0787)	(.1033)	(.0683)	(.0778)
COFD price	P_6	.3271	.0682	.3435	-.0498	-.1097	.1398
		(.1143)	(.1665)	(.1177)	(.1632)	(.0781)	(.1055)
FCOS price	P_7	.0593	.1260	-.0141	.1170	.0286	.0164
		(.0852)	(.1073)	(.0693)	(.0913)	(.0564)	(.0677)
POD price	P_8	.2796	.2168	.1006	.2452	.1616	-.1468
		(.1345)	(.1888)	(.1347)	(.1832)	(.0884)	(.1206)
q_{t-1}		-.6748	.4926				
		(.1391)	(.1737)				
FB_{t-1}				-.8583	.3603		
				(.3461)	(.2249)		
PH_{t-1}						-.0665	.2405
						(.1248)	(.2296)
Income	I	1.7257	1.9843	.2800	1.5663	.4727	.3806
		(.2534)	(.6844)	(.2299)	(.6365)	(.1500)	(.2286)
Seasonality	S	.0508	.0207	.0404	.0130	.0765	.0125
		(.0010)	(.0127)	(.0122)	(.0109)	(.0059)	(.0073)
ρ_1		.1248	-.2166	-.2682	-.3427	.1032	-.2339
		(.1058)	(.1052)	(.1045)	(.1019)	(.1044)	(.1055)
ρ_2		-.2471	-.1253	---	---	-.2700	---
		(.1058)	(.1052)	(---)	(---)	(.1044)	(---)
R^2 [c]		.93	.94	.66	.82	.84	.68
F		87.27	113.5	12.7	31.2	35.2	14.0

[a]Standard errors are in parentheses below the coefficients.

[b]Variable definitions are as follows:

FCOJ price = Market Research Corporation of America (MRCA) retail price of frozen concentrated O. J. (¢/6-oz.) deflated by Consumers Price Index (CPI).
COJ price = MRCA retail price of chilled O. J. (¢/32-oz.) deflated by CPI.
CSSOJ price = MRCA retail price of canned O. J. (¢/46-oz.) deflated by CPI.
FCOD price = MRCA retail price of frozen concentrated orange drink (¢/6-oz.) deflated by CPI.
COD price = MRCA retail price of chilled orange drinks (¢/64-oz.) deflated by CPI.
COFD price = MRCA retail price of canned orange flavored fruit drinks (¢/64-oz.) deflated by CPI.
FCOS price = MRCA retail price for frozen concentrated orange synthetics (¢/12-oz.) deflated by CPI.
POD price = MRCA retail price for powdered orange drinks (¢/18-oz.) deflated by CPI.

[c]Calculated using sums of squares after transformation.

variable on the current and lagged ordinary independent variables and using the predicted values to substitute for the lagged dependent variable in equation 2. These predicted values are uncorrelated with the error term because they are linear combinations of variables that are assumed to be uncorrelated with e_t. After the substitution the equations are estimated assuming the error structure:

$$(4) \qquad e_t = \varrho_1 e_{t-1} + \varrho_2 e_{t-12} + \mu_t$$

or

$$(5) \qquad e_t = \varrho_1 e_{t-1} + \mu_t$$

where $|\varrho_1| < 1$, $|\varrho_2| < 1$, and μ_t are normally and independently distributed errors with zero mean and a constant variance. Equation 4 is assumed as long as ϱ_2 is estimated to be greater than its approximate standard error. Data for the January 1972 through January 1979 period (85 observations) are used to estimate the equations.

INTERPRETATION AND IMPLICATIONS

Parameter estimates and their associated approximate standard errors for the six equations are shown in Table 1. The parameters for the price and income variables in the six equations are estimates of the short-run own-price, cross-price, and income elasticities.[3]

The coefficients for the lagged dependent variables are estimates of $(1-\phi)$ for each equation and can be used to calculate long-run elasticity estimates from the short-run elasticities that are estimated parameters. Table 2 contains some of these parameters for the six equations along with the estimated adjustment period.

The coefficients in Tables 1 and 2 indicate that the demand relationships for FCOJ and COJ are different with respect to habit/inventory dominance, price elasticity, and income elasticity.

The coefficient for lagged FCOJ purchases indicates inventory-type dominance which means that the short-run price response (−1.4) is greater than the long-run fully adjusted

TABLE 2. SHORT-RUN, LONG-RUN RESPONSES TO PRICES, AND LENGTH OF ADJUSTMENT PERIOD, FCOJ AND COJ

Product-equation (Dependent variable)	Lag Coefficient ϕ	Price elasticities: Short-run $\phi\beta$	Price elasticities: Long-run β	Adjustment period[a]
		- percentage change -		months
FCOJ				
Per capita consumption (q_t)	1.6748	-1.4385	-.8589	8
Percent of families buying (PB_t)	1.8583	-.8048	-.4331	7
Purchases per buying household (PH_t)	1.0665	-.5906	-.5538	1
COJ				
Per capita consumption (q_t)	.5074	-.4300	-.8474	5
Percent of families buying (PB_t)	.6397	-.2893	-.4522	3
Purchases per buying household (PG_t)	.7595	-.2648	-.3487	3

[a]The adjustment period is the length of time it takes for 95 percent of the effect to occur. The long-run coefficient is: $\lim_{J\to\infty} \sum_{j=0}^{J} (-\phi)^j \phi\beta = \beta$. Thus, the adjustment period is the minimum J* such that: $\left(\frac{\sum_{j=0}^{J^*} (1-\phi)^j}{\sum_{j=0}^{\infty} (1-\phi)^j} \right)$ is greater than .95 for habit dominance or less than 1.05 for inventory dominance effects.

[3]As with any regression model, the interpretation of any set of parameter estimates is subject to the particular model's specification. Specification bias due to exclusion of some potential substitute prices is not expected to be great. Alternative specifications of the set of substitutes does not materially alter the coefficient estimates.

price response (−.86) (Table 2). The length of the adjustment period is eight months (Table 2).

For FCOJ, percentage of families buying (FB_t) and purchases per buying household (PH_t) both exhibit inventory-type responses. The inventory response is much stronger for FB_t than for PH_t. This finding identifies the primary source of the inventory-type response as changes in numbers of buyers rather than purchases per buyer. Purchases per buyer increase only slightly when percentage of families buying increases. It is not possible to determine whether consumers' consumption rate also changes or whether the consumption rate is relatively constant and the product is actually kept in inventory for consumption in nonpurchase periods.

These results suggest an alternative explanation of inventory-type dominance. Rather than product stocking, the observed phenomenon may be short-term product switching. That is, consumers enter and buy, then exit, and while they are not purchasing they may either consume from inventory, cease to consume, or consume substitute products. On the basis of aggregate per capita purchases, it is not possible to determine which of the phenomena is occurring. Given the results for FCOJ, entry and exit rather than product stocking appears to be the primary source of the inventory-type response.

The three equations for COJ lead to substantially different conclusions about habit-inventory dominance. For COJ, the coefficients indicate that habit effects dominate—a positive relationship between current and lagged consumption was found. Habit effect dominance means that the short-run price response (−.43) is less than the long-run response (−.85) because the purchase habit takes time to change. The length of the adjustment period is estimated to be five months. The equations for both the percentage of families buying and the ounces per buying household show similar habit-type response properties.

The two products also differ with respect to the estimates of the short-run cross-price elasticity. Three of seven possible substitute prices in the FCOJ per capita purchases equation have positive coefficients that are more than twice their approximate standard errors. In the COJ per capita purchases equation, none of the seven possible substitute prices have positive coefficients that are more than twice their approximate standard errors. In the FCOJ equation, the COJ price has a positive coefficient 1.8 times larger than its standard error whereas in the COJ equation, the FCOJ price has a negative coefficient less than one-half as large as its approximate standard error. This finding means that the COJ prices may have a short-run impact on FCOJ consumption, but the reverse is apparently not true. The long-run cross-elasticity results would have the same relationship as the short- and long-run own-price elasticity parameters shown in Table 2. That is, for FCOJ, the long-run substitution effects would be lower than the short-run effects whereas the reverse would be true for COJ.

The FCOJ and COJ results suggest that the two products' characteristics are particularly important in the analysis of short- and long-run adjustments to price changes. Though the short-run own-price elasticity for FCOJ was estimated to be 3.3 times greater than the short-run own-price elasticity for COJ, the long-run FCOJ and COJ elasticity estimates are approximately equal.

MARKETING IMPLICATIONS

The importance of the dynamic adjustment process is especially apparent in the analysis of the impact of exogenous shocks on consumption patterns. The most severe shocks to orange product markets are freeze conditions that have rendered part of the crop unusable in 1958, 1963, 1971, and 1977. The 1977 freeze resulted in reduced juice production levels for the 1976-77 and 1977-78 seasons and had some negative carryover effect on the 1978-79 crop. Real retail prices before the 1977 freeze were at near record low levels, and since the freeze real prices have been higher than previously.

In post-freeze recovery periods, key questions that face the industry include:

1. At what price levels will the new crop be sold?
2. Should marketing efforts be addressed to percentage of families buying or usage per household?

An outlook simulation program,[4] which employed dynamic demand relationships, has been used to evaluate alternative crop sizes and price adjustments. The simulation results include FCOJ and COJ total sales levels, percentages of families buying, and ounces per buying household. Prior to the 1978-79 season, continuation of 1977-78 prices was estimated to be feasible if the crop were 185 million boxes. After release of the 1978-79 crop forecast of 168 million boxes, FCOJ wholesale prices were raised. According to the simulation model results, FCOJ aggregate sales, percentage of families buying, and ounces per buying household were expected to be below prefreeze levels even at a 185 million box crop

[4]Full documentation of the program is beyond the scope of this article. Some background on the interworkings of the program is described by Myers [4].

and constant nominal wholesale prices. FCOJ trends in all three variables were estimated to be stable to slightly increasing throughout the period. For COJ substantially different expectations were projected. Retail sales and percentage of families buying and ounces per buying household were projected to continue increasing. Both the expected sales levels and number of buyers were expected to exceed prefreeze observations.

The relative rates of growth for the two products reflect trends that were in evidence prior to the freeze. The projections indicate that post-freeze price levels have not stalled the tendencies for more rapid COJ growth. Thus, even though FCOJ sales are expected to be relatively stable, COJ sales are expected to provide strong demand growth which has provided the basis for higher price levels.

In other experiments, the effects of retail level price reductions of alternative magnitudes, time periods, and length of time were estimated. In general, the net effect of an FOB price promotion was found to be positive. Some but not all of the purchase gains for FCOJ in the price reduction period are offset by purchase reductions during the post-price reduction period. For COJ, sales gains from retail price reductions carry over into periods following the price reduction period. In addition, price promotion timing, length, and magnitude were found to be important determinants of promotion effectiveness.

CONCLUSIONS

The importance of understanding consumption dynamics in market periods following exogenous shocks is shown. Processed orange product characteristics are important determinants of whether habit or inventory effects dominate and the nature of the demand relationship. On the basis of monthly data, FCOJ exhibits inventory-type dominance and COJ exhibits habit-type dominance. In addition, the relative importance of rigidities in percentage of families buying and ounces per buying household is determined and reported. These analyses reveal that the inventory-type dominance for FCOJ is related more closely to entry and exit of consumers than to fluctuating purchases and inventory holding by consumers.

The models reveal the importance of recognizing that the total effect of any price change is not immediately known and that FCOJ and COJ have substantially different types of responses to price changes.

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