Aggregate Fruit Price Equations and Conditional Price Forecasts

by

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Problem Statement and Objectives

Both per capita consumption and nominal prices of fruit have steadily increased over the last several years. Consumption in 1983 totaled 236.1 pounds per person (fresh weight equivalent), up from 199 pounds in 1960, while nominal fruit prices (as measured by the consumer and producer price indexes) rose between 160 and 310 percent over the same period.

Several factors explain the growth in consumption. At the farm level, improved cultural practices, increased mechanization, and a shift in producing acreage to the West's productive irrigated farmlands allowed fruit growers to double their 1980 output over that of 1950 while harvesting fewer acres. Lower real and nominal prices for the consumer were the result. The increased consumer acceptance of "new" varieties of fruits (e.g., delicious apples, navel oranges, Thompson seedless grapes) as well as the commercial introduction of fruits such as avocados, nectarines, and kiwifruit also promoted greater consumption. Furthermore, the advent of controlled-atmosphere storage extended the marketing season for apples and pears. Beyond the farm gate, improvements in refrigeration and the transportation system broadened the spatial and temporal markets for fruit. At the same time, advances in processing technologies gave rise to increased consumption of processed fruits. Frozen concentrate orange juice was the most dramatic example [Huang and Kuwamoto (1980)]. The marketing-oriented U.S. food manufacturing industry aids consumption by continually introducing new products. Recent examples include aseptically packaged fruit drinks and granola fruit bars. Active advertising and promotion campaigns have also stimulated use.

Demand factors motivated the above fruit supply changes. Most importantly, increased consumer incomes appear to have boosted the demand for and consumption of fruits [Huang and Kuwamoto]. Related to the higher incomes are consumers' demands for more convenience foods, which spurred the consumption of processed fruit products. Finally, changes in consumers' tastes and preferences may have brought about increased fruit consumption.

However, the general increase in per capita consumption obscures the dramatic shift in the composition of fruit consumption over the last three decades. Most fruit was consumed fresh before the early 1950s. A breakthrough in processing technology led to the marketing of new processed products, especially for citrus. Fresh consumption subsequently declined from 118 pounds (farm weight), per capita, in 1951 to a low 74.7 pounds during the 1963 freeze year. Since then, fresh fruit consumption has oscillated, from a low of 76.3 pounds in 1973 to a high of 87.3 in 1980. In contrast, total processed per capita consumption has trended upward, from 90.2 (fresh weight) pounds in 1953 to 143.5 in 1975, and averaged 137.7 pounds over (1976-1980). Most of this increase can be attributed to gains in per capita consumption of frozen fruit products. The combined consumption of canned fruit and canned and chilled fruit juice rose steadily, until the 1969 high of 63.9 pounds (fresh weight equivalent), and has since shown a weak downtrend. Higher juice consumption has partially offset waning canned fruit use. Dried fruit has experienced a variable consumption pattern. Per capita consumption of dried fruit gradually declined from the 1950s until 1972, when bad weather damaged much of the crop and consumption plummeted almost 25 percent to 7.3 pounds. Since 1972, consumption of dried fruit has fluctuated, depending upon the weather, and has averaged 9.3 pounds per person between 1973 through 1980.

As mentioned earlier, the nominal prices of fruits have risen steadily over the past three decades. Between 1960 (1970) and 1983, the retail price index for fresh fruits rose 242 (167) percent; the wholesale price index for canned fruits and juices gained 206 (156) percent; the wholesale price index for dried and dehydrated fruits jumped 314 (242) percent. This compares with the 221 (136) percent rise in the prices of all food. Both inflation and consumer income probably account for much of these fruit price gains as suggested by the empirical evidence presented below.

Inflation of the general price level has been a primary influence on fruit prices, mainly through its effects on marketing costs. Over time, increases in marketing costs have closely paralleled the rate of inflation. Furthermore, the relationship between retail fruit prices and the general price level have become tighter because of the additional marketing services included with fruit products.

The major reason why processed fruit seems to have replaced fresh fruits as a consumer favorite is because the factors listed above have largely favored processed fruit consumption, with frozen concentrate orange juice a major beneficiary. There is some evidence that an increase in the demand for convenience foods has occurred as leisure time has expanded and as a greater number of households have had two wage earners [see Huang and Kuwamoto].

Our study considers the importance of traditional economic variables like per capita consumption, disposable income and inflation in explaining the nominal price patterns of fresh, frozen, dried, and canned fruit. A series of four econometric models are developed to explain historical price patterns and to make conditional forecasts from 1985 to 1989. These forecasted fruit price trends provide information to the fruit industry for production and investment decision-making.

Methodology

The theory of consumer demand asserts that the nominal price of a commodity is determined by per capita consumption of that commodity, per capita consumption of complements and/or substitutes, consumer's per capita income and an inflation factor. Per capita consumption of a good should vary inversely with the price of that good. If per capita consumption of substitute (complementary) products increase, then the price for the good in question should decrease (increase). Income relationships can be either positive or negative depending upon whether the commodity in question is a normal or inferior good. Since past studies [e.g., Nuckton (1978)] indicate all forms of fruit are normal goods, we hypothesize a positive relationship between income and price. Inflationary influences on fruit prices can be either positive or negative depending on the source(s) of inflation.

A general model specification for estimating the own price forecasting system is:

$$P_i = f(Q, YPD, PCND\text{-}F),$$

where

i = Fresh, frozen, canned or dried fruit,

P_i = Own (retail) wholesale price of either (fresh) frozen, canned or dried in fruit,

Q_i = Own per capita consumption of either fresh, frozen, canned and chilled or dried fruit,

YPD = Per capita disposable income,

and

PCND-F = CPI for non-durable goods less food.

Retail price indices for frozen, canned and chilled, and dried fruit do not exist. Therefore, in estimating the models we assumed retail prices are marked up by a constant margin from the wholesale level and then used the wholesale price indices as proxies for frozen, canned, and dried fruit retail prices.

Data and Estimation Results

Data for retail prices (fresh fruit) and wholesale prices (canned fruit and juices, frozen fruit and juices and dried fruit) are published monthly in departmental news reports from the U.S. Department of Labor, Bureau of Labor Statistics. Per capita fruit consumption data are available from the U.S. Department of Agriculture, Economic Research Service. In particular consumption figures prior to 1970 can be found in the Fruit Outlook and Situation report (July, 1981) and the revised current consumption data are located in the Fruit Outlook and Situation report (forthcoming October, 1985). Data for disposable income and the CPI for non-durable goods less food are found in various issues of the Monthly Labor Review, Bureau of Labor Statistics.

Econometric models were estimated over the time period 1960-1980. Table 1 presents the demand models. The estimation technique chosen was the Cochrane-Orcutt procedure since the Durbin-Watson statistic in initial OLS estimates indicated autocorrelation for all four equations. When a model is observed to have autocorrelation, prediction can be enhanced by making use of information from the disturbances.

Consider the model

$$Y_t = \alpha + \beta X_t + u_t$$

where: $u_t = \rho u_{t-1} + \varepsilon_t$

The best predictor for this model with n sample observations will result from

$$Y_t - \rho Y_{t-1} = \alpha(1-\rho) + \beta(X_t - \rho X_{t-1}) = \varepsilon_t$$

which can be rearranged as

$$Y_t = \alpha + \beta X_t + \rho(Y_{t-1} - \alpha - \beta X_{t-1}) + \varepsilon_t$$

giving the predictor

$$\hat{Y}_{n+1} = \alpha + \beta X_{n+1} + \hat{\rho} u_n$$

Every coefficient in each equation has the expected sign. A perusal of $\bar{R}^2$ and asymptotic t-statistics of the regression models indicates the price forecasting model is fairly successful in explaining past variation.

Projection Assumptions

Forecasting with an econometric model requires some assumptions. First, the model must reflect the economic behavior of consumers. Performance statistics mentioned below tend to corroborate this assumption. Second, consumer behavior described by the model must remain constant in the future. However, the longer the forecasting time horizon, the more carefully this assumption should be reexamined. Finally, a number of exogenous factors need to be given future values for estimation. Values for these factors are generally found by using the projections of other analysts or by assuming recent past trends continue in the future.

Table 1

Aggregate Fruit Price Forecasting Equations 1/

Dependent Variables 2/	FFCPI	CCFPPI	FRFPPI	DFPPI
Intercept	.496 (1.362) 3/	.830 (3.307)	1.265 (3.453)	.300 (.359)
Own per capita consumption	-.0036 -(0.817)	-.0127 (-3.069)	-.018 (-2.755)	-.045 (-.665)
YPD	.3170 (4.260)	.2270 (4.766)	.3742 (2.361)	.514 (2.092)
PCND-F	-.040 (-0.140)	.297 (1.500)	-.251 (-.391)	-.081 (-.077)
$\bar{R}^2$ 4/	.99	.99	.87	.94
ρ 4/	.831	.401	.513	.448
SEE 4/	.067	.048	.163	.260

1/ Method of estimation was generalized least squares using Cochrane-Orcutt procedures.

2/ Variable names and descriptions:

FFCPI = Fresh Fruit CPI	(1967 = 1.00)
CCFPPI = Canned Fruit and Juices WPI	(1967 = 1.00)
FRFPPI = Frozen Fruit and Juices PPI	(1967 = 1.00)
DFPPI = Dried Fruit PPI	(1967 = 1.00)
FFC = Per Capita Consumption of Fresh Fruit	(lbs.)
CCFC = Per Capita Consumption of Canned and Chilled Fruit	(lbs.)
FRFC = Per Capita Consumption of Frozen Fruit	(lbs.)
DFC = Per Capita Consumption of Dried Fruit	(lbs.)
YPD = Per Capita Disposable Income	(1,000 $)
PCND-F = CPI on Non-Durables Less Food	(1967 = 1.00)

3/ Numbers in parentheses are asympototic t-values.

4/ $\bar{R}^2$ = Corrected correlation coefficient
SEE = Standard error of the regression
ρ = rho estimated

Table 2

Exogenous Variable Forecast Assumptions 1/

YEAR	FFC	DFC	FRFC	CCFC	YPD	PCND-F
		------------ Pounds ------------			1000$	1967=1.00
1985	86.99	10.54	74.98	44.68	10.02	2.609
1986	87.84	10.61	76.09	44.95	10.813	2.724
1987	88.61	10.63	75.65	45.03	11.643	2.846
1988	89.47	10.67	77.56	45.21	12.201	3.012
1989	90.16	10.69	78.08	45.3	13.097	3.227

1/ See footnote to Table 1 for variable definitions and units.
FFC, DFC, FRFC, and CCFL were derived from ERS's 10-year baseline forecasts.
YPD and PCND-F were obtained from an econometric consulting firm's forecasts.

This last assumption is most tenuous for projecting fruit prices. A key reason is the sensitivity of fruit consumption, particularly citrus, to weather conditions. A severe freeze can reduce citrus production for several years by damaging the groves, reducing citrus supply, and ultimately consumption. Net exports of fruit may also change dramatically. Both of these developments will affect aggregate fruit price through the consumption variable. In our projections, values for per capita disposable income and the non-durables less food CPI were taken from an econometric forecasting firm's baseline forecasts. The fruit consumption figures were based on ERS's 10-year baseline assessments. Exogenous value assumptions are listed in Table 2.

Before one can determine whether or not these wholesale and retail price patterns mentioned earlier will continue in the future, the model should be tested for forecasting reliability. Table 3 presents some within sample evaluation statistics. There are a number of goodness-of-fit measures for evaluating forecasts [see Tomek and Robinson (1981) for a discussion]. Four commonly employed measures are the mean absolute error (MAE), the mean absolute percent error (MAPE), the mean squared error (MSE) and the Theil inequality coefficient (U_2). The mean absolute error ranges from .223 units for dried price to .043 units for canned price. The mean absolute percentage error ranges from a little over 15 percent for dried price to a little over 3 percent for canned and chilled price. Mean error squared is highest for dried price at .069 units and lowest for fresh fruit at .013 units. The Theil U_2 coefficient [see Theil (1966) and Leuthold (1975)] has a lower bound of zero suggesting perfect forecasts. A U_2 value of one implies that forecasts are no better than the naive no-change extrapolations. All four equations have values between zero and one and indicate the equations track the prices well within the sample period.

Table 3

Within Sample (1960-1980) Evaluation Statistics

Dependent Variable	Mean	Mean Absolute Percentage Error	Theil's U_2 Inequality Coefficient	Mean Absolute Error	Mean Error Squared
DFPP	1.7535	15.27	.693	.223	.069
FFCPI	1.4971	7.56	.441	.094	.013
FRFPPI	1.4922	10.48	.680	.146	.029
CCFPPI	1.3813	3.34	.354	.043	.024

Table 4

Out of Sample Evaluation Statistics 1/

Dependent Variable	Mean Absolute Percentage Error	Mean Absolute Error	Mean Error Square
DFPPI	13.84	.542	.325
FFCPI	5.48	.167	.037
FRFPPI	10.35	.337	.155
CCFPPI	7.75	.217	.054

1/ Due to data limitations, use of a consistent forecast evaluation period was not possible. Out of sample forecast evaluation periods used were: dried (1981-1983), fresh (1981-1984), frozen (1981-1984) and canned and chilled (1981-1982).

Table 5

Econometric Model Price Forecasts, 1985-1989

Year	Fresh	Canned	Frozen	Dried
		Index		
		Nominal Prices		
1985	3.2513	3.3128	2.9957	4.7709
1986	3.4949	3.5236	3.2434	5.1665
1987	3.7504	3.7472	3.5314	5.5828
1988	3.9174	3.9209	3.6639	5.8548
1989	4.1903	4.1870	3.9358	6.2977
		Real Prices 1/		
1985	1.2462	1.2697	1.1482	1.8286
1986	1.2830	1.2935	1.1907	1.8966
1987	1.3178	1.3166	1.2408	1.9616
1988	1.3006	1.3017	1.2164	1.9438
1989	1.2985	1.2975	1.2196	1.9516

1/ Nominal prices deflated by PCND-F projections.

A robustness test is another way to assess the forecasting ability of the four price forecasting equations. This test basically compares forecasts from these equations beyond the sample period with actual values. Table 4 shows some out of sample forecast evaluation statistics.[1] Data limitations restricted use of a uniform forecast evaluation periods.[2] Overall, the econometric model seems to be a satisfactory forecaster for out of sample forecasts.

Forecasts and Implications

The nominal and real price forecasts for 1985-1989 are shown in Table 5. Nominal fresh fruit CPI price is predicted to rise from 3.25 in 1985 to 4.19 in 1989 (an increase of 29 percent), nominal canned fruit WPI price is forecasted to rise from 3.31 in 1985 to 4.19 in 1989 (an increase of 27 percent), nominal frozen fruit WPI price is predicted to rise from 3.00 in 1985 to 3.94 in 1989 (an increase of 31 percent), and nominal dried fruit WPI is predicted to rise from 4.77 in 1985 to 6.30 in 1989 (an increase of 32 percent). Accounting for anticipated inflation, real fresh price rises from 1.25 in 1985 to 1.30 in 1989 (an increase of 4 percent), real canned prices increase from 1.27 in 1985 to 1.30 in 1989 (an increase of 2 percent), real frozen fruit price is forecasted to rise from 1.15 in 1985 to 1.22 in 1989 (an increase of 6 percent), and real dried price is predicted to rise from 1.83 in 1985 to 1.95 in 1989 (an increase of 7 percent).

Our forecast results suggest fruit prices will increase faster than income and the CPI on nondurable goods less food. These forecasts of rising nominal and real fresh and processed fruit prices may be encouraging signs for the U.S. fruit industry if they are not related to marketing cost increases. A comparison of relative price increases suggest the increased demand for convenience foods plays an important role in explaining fruit price patterns. As consumers substitute processed fruit for fresh fruit consumption, larger price increases are expected for processed fruit than fresh fruit.

Endnotes

[1] The Theil U_2 coefficient values were not calculated due to the limited number of observations.

[2] The 1984 dried fruit per capita consumption estimate is not available at this time because data for raisins and prunes consumption will be published at a latter date. The 1983 and 1984 canned and chilled citrus fruit per capita consumption data are no longer being published by the Florida Citrus Processors' Association. Also, the 1984 non-citrus canned fruit and canned juice per capita consumption data are not comparable with 1983 because of significant erosion in the participant base for applesauce, apple slice, and apple juice. The National Food Processors' Association has suspended publication of statistical reports for apple products.

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