# FOOD DEMAND ANALYSIS

## Implications for Future Consumption

Edited by

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# ORANGE AND GRAPEFRUIT JUICE DEMAND FORECASTS

Mark G. Brown and Jonq-Ying Lee[1]

## Introduction

Citrus consumption in the United States has expanded dramatically over the past decades with per capita consumption of citrus products growing from 2.2 pounds in 1920 to 117.5 pounds in 1980. In addition, over this period the form in which citrus is consumed has changed substantially. Up until the 1940's most citrus was consumed fresh. However, over the period from 1940 to 1980, per capita consumption of fresh citrus declined by about 50%, while per capita consumption of processed citrus products increased nearly ninefold. This turnaround can be attributed largely to the introduction of canned juice in the 1920's and frozen concentrate in the mid 1940's. These developments are summarized below in Table 1.

Table 1
U.S. Citrus Per Capita Consumption

| | 1920 | 1940 | 1960 | 1980 |
|---|---|---|---|---|
| | -------fresh weight equivalent pounds------- | | | |
| Fresh[a] | 22.2 | 52.1 | 30.7 | 26.3 |
| Processed | 0[b] | 10.4 | 52.2 | 91.2 |
| Total | 22.2 | 62.5 | 82.9 | 117.5 |

[a]Excludes lemons and limes.

[b]None reported.

Source: Gunter (1984).

In the coming years, it is anticipated that the overall demand for citrus products will continue to grow, and there will be further changes in the specific forms in which citrus is consumed. In this paper, attention is focused on the expected growth in the demand for processed

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citrus products, the dominant form in which citrus is now consumed. In particular, the demands for different forms of orange and grapefruit juice are explored, with the primary objective being to forecast demands to the year 2000. Demand forecasts for six citrus juices -- frozen concentrated orange juice (FCOJ), chilled ready-to-serve orange juice (COJ), canned single strength orange juice (CSSOJ), frozen concentrated grapefruit juice (FCGJ), chilled ready-to-serve grapefruit juice (CGJ), and canned single strength grapefruit juice (CSSGJ) -- are reported.

The paper is organized as follows. First, factors expected to be related to consumer demands for citrus juice products are discussed. Following this, the citrus juice demand specifications used in this study are developed. Next, the data employed are described. Then statistical results -- estimates for the demand equations and forecasts -- are discussed. Finally, some concluding remarks are offered.

## Demand Factors

In this section, factors expected to be important in determining the demands for citrus juice products are discussed. These factors range from prices and income to measures related to preferences, product quality, and household production theory. Where it was possible, the demand factors discussed in this section have been employed in developing the demand forecasts of this study.

### Prices and Income

Prices and income are expected to have their usual demand effects as suggested by theory. Major cross-product relationships are anticipated to be between the citrus juice products and other foods. In subsequent modeling, a two-stage budgeting process is used to formulate these relationships. In the first stage, total income is allocated to broad commodity groups, food being one such group, while, in the second stage, the amount of total income allocated to each commodity group is spent on individual commodities within the group. This paper is concerned with the second stage allocation of income allocated to the food group to the different citrus juice products. In this case, the citrus juice demands can be made functions of total income allocated to food and the prices of individual food commodities only.

### Women in the Labor Force

Over the past several decades, more and more women have entered the labor force, as indicated by the steady increase in the female labor force as a percent of the female population (Table 2).

This trend has had a wide range of social and economic impacts. For our concern, citrus juice consumption, this development appears to be related to convenience in consumption. In particular, with more women spending time at work and having less meal preparation time, it is

Table 2
Female Labor Force Participation

| Year | Female Labor Force as Percent of Female Population |
|---|---|
| 1940 | 27.4 |
| 1950 | 31.4 |
| 1960 | 34.8 |
| 1970 | 42.6 |
| 1975 | 46.0 |
| 1980 | 51.1 |
| 1982 | 52.1 |

Source: U.S. Department of Commerce, Bureau of Census (1984b).

hypothesized that women, the principal meal planners, are placing a greater value on convenience in food preparation. For orange and grapefruit juice, the implication is that over time the more convenient product forms such as COJ and CGJ may have become more appealing relative to the less convenient forms such as FCOJ and FCGJ which require preparation time.

## Age Structure of the Population

Since 1970, there has been an overall aging of the U.S. population, the median age increasing from 27.9 in 1970 to 30.6 in 1982. This trend is expected to continue into the future with the median age projected to reach 36.3 by year 2000 (U.S. Department of Commerce, Bureau of Census, 1984a). In addition, the number of persons in specific age groups should experience major changes in the coming years. It is expected that from 1985 to 2000, the people aged 18 to 24 years old will decrease in number by about 4 million; the people aged 25 to 34 will decrease by about 5 million; the people aged 35 to 44 will increase by about 12 million; the people aged 45 to 64 will increase by about 16 million; and the people aged 65 and over will increase by about 6 million. Major changes in the age structure of the population are summarized in Table 3.

For citrus juice consumption, perhaps, a more mature population will have a greater recognition of the health value associated with citrus juice and thus will have a positive impact on the overall demand for citrus juice. In an earlier study, Ward and Davis (1978) found that the age of the consumer was a determinant of the demand for FCOJ.

Table 3
Projected U.S. Population, By Age

| Year | Total Population, By Age, in Thousands | | | | |
|---|---|---|---|---|---|
| | 18-24 | 25-34 | 35-44 | 45-64 | 65 & over |
| 1985 | 28,739 | 41,788 | 32,004 | 44,652 | 28,608 |
| 1990 | 25,794 | 43,529 | 37,847 | 46,453 | 31,697 |
| 1995 | 23,702 | 40,520 | 41,997 | 52,320 | 33,887 |
| 2000 | 24,601 | 36,415 | 43,743 | 60,886 | 34,921 |

Source: U.S. Department of Commerce, Bureau of Census (1984a).

## Lifestyle Changes

Lifestyle changes associated with decreasing family sizes, increasing numbers of single people, and a historic trend toward urbanization have probably had an impact on citrus juice demands, perhaps favoring product forms that are convenient. From 1970 to 1980, the average family size decreased from 3.14 to 2.76 persons, the percent of the population 18 years and older being single increased from 16.2 to 20.3, and the percent of the population living in metropolitan areas increased from 68.6 to 74.6 (U.S. Department of Commerce, Bureau of Census, 1984b).

## Citrus Juice Promotion

The citrus industry has continually promoted its products, particularly orange juice, over the past years. It is expected that such promotion will continue and, in fact, grow. Advertising, coupons, and other promotional programs have been carried out by both private firms and the Florida Department of Citrus (FDOC). For example, expenditures on generic advertising for orange juice in the United States in 1982 by the FDOC was about $15.4 million, while brand advertising for orange juice by private firms was about $12 million (FDOC and Leading National Advertisers Reporting Service). The expenditures are for media only, excluding expenditures for promotion and merchandising. In 1981 and during the 1970's, FDOC advertising expenditures, relatively stable in real terms, also exceeded brand advertising expenditures. However, in 1983 this trend was reversed with brand advertising expenditures of about $30 million and FDOC advertising expenditures of about $15 million.

Previous studies (Lee, 1981; Ward and Davis, 1978) have shown that specific promotional programs have had significant impacts on expanding citrus juice consumption. Promotion in the last year appears to have been particularly important. In September 1983, Proctor and Gamble

Company introduced Citrus Hill orange juice, spending millions on advertising. Coca-Cola Company (Minute Maid) and Beatrice Companies (Tropicana) shortly countered, promoting their orange juice products. These promotional activities will probably not only alter market shares among firms but also expand the market in general.

## Promotion: Preferences Related to Age and Product Quality

Generally, consumer demands can be made functions of both preferences and product quality (Deaton and Muellbauer, 1980; and Hanemann, 1982). From this viewpoint, promotion can affect demand by not only changing consumer preferences but by also providing information about product quality. For example, 100% juice blends are presently being promoted, specifically targeting the under eleven year old population which is expected to increase in size in the coming years. The different juice blends will be offered in aseptic packages as well as cans and bottles. The aseptic packages are handy for school lunches. Other promotions for 100% juice blends are specifically targeting the entire family and adults.

## Trends in Packaging and Product Quality

In recent years, major packaging and product quality developments have occurred in the citrus industry (de Jager, 1984). Low acid FCOJ tailored for consumers with problems with acidity, high pulp juice perceived as natural and healthy, and other alternative orange juice products differing in quality have been offered to consumers. As mentioned, aseptic packaging allowing for more convenience in consumption is also being introduced in the citrus industry. Aseptic packed juice does not require refrigeration and can be conveniently consumed almost anywhere, offering a means to expand juice consumption away from home.

## At and Away From Home Food Expenditures

Over the past years, food away from home has become a more important budget item relative to food at home. From 1960 to 1980, the percent of disposable personal income allocated to food at home has decreased from 16.0 to 12.1, while the percent of disposable personal income allocated to food away from home has slightly increased from 4.0 to 4.3. In combination, the percent of disposable personal income allocated to food at and away from home has decreased from 20.0 to 16.4 over this period. These expenditure changes are summarized below in Table 4.

The shift towards food away from home may have occurred because of rising incomes, relative price changes, and/or preference shifts. Perhaps for the citrus juices, this trend indicates changes in favor of convenient juices consumed away from home. The recent development of ready-to-serve citrus juice packed in aseptic containers may be one reflection of this trend.

Table 4
Food Expenditures at Home and Away from Home

| Year | Disposable Personal Income | Food Expenditures | | | | | |
|---|---|---|---|---|---|---|---|
| | | At Home | | Away From Home | | Total | |
| | mil. $ | mil. $ | Pct. | mil. $ | Pct. | mil. $ | Pct. |
| 1960 | 351,992 | 56,244 | 16.0 | 14,234 | 4.0 | 70,478 | 20.0 |
| 1970 | 695,288 | 91,956 | 13.2 | 27,686 | 4.0 | 119,642 | 17.2 |
| 1975 | 1,096,068 | 139,407 | 12.7 | 45,813 | 4.2 | 185,220 | 16.9 |
| 1980 | 1,824,076 | 221,542 | 12.1 | 78,435 | 4.3 | 299,977 | 16.4 |

Source: U.S. Department of Agriculture.

## Season of the Year

Past studies (Myers and Liverpool, 1972; Ward and Davis, 1978; Ward and Tilley, 1980; and Tilley, 1979) have found that the citrus juice demands have varied over season of the year. For example, based on Myers and Liverpool's findings, the demand for FCOJ appears to decrease during the summer while the demand for COJ appears to increase. Perhaps, in the summer months, consumers favor convenience as hot weather arrives, school children return home, and family outings and vacations are taken. These and other seasonal shifts may have been alleviated to some extent by the extended product usage campaign by the FDOC. This campaign stressed the extended uses of orange juice beyond the use at the breakfast occasion, i.e., orange juice is good any time.

## Population Growth

Population is expected to be a major determinant of demand. The total U.S. demand forecasts of this study are obtained by multiplying per capita forecasts by projected populations. As reported in Table 5, the U.S. population grew by about 33 million from 1965 to 1980, and, although the growth rate is slightly declining, the U.S. population should grow by about another 29 million from 1985 to 2000.

## Demand Specifications

Employing the previously discussed demand factors where possible, the demands for the different forms of orange and grapefruit juices are modeled in per capita terms (Parks and Barten, 1973; Deaton and Muellbauer, 1980; Brown and Deaton, 1972). The per capita demands can be

Table 5
U.S. Population Estimates and Projections

| Total U.S. Population | | | |
|---|---|---|---|
| Year | Estimate | Year | Projection |
| 1965 | 194,303 | 1985 | 238,631 |
| 1970 | 205,052 | 1990 | 249,657 |
| 1975 | 215,973 | 1995 | 259,559 |
| 1980 | 227,704 | 2000 | 267,955 |

Source: U.S. Department of Commerce, Bureau of Census (1984a).

rationalized as follows. Assume a representative or average consumer with utility function $U = U(q_1/N,\ldots,q_9/N,Z)$ and budget constraint $y/N = \sum_{i=1}^{9} p_i q_i/N$ where $p_i$ and $q_i$ are the price and quantity for the total United States for the $i^{th}$ good, i = 1 for FCOJ, i = 2 for COJ, i = 3 for CSSOJ, i = 4 for FCGJ, i = 5 for CGJ, i = 6 for CSSGJ, i = 7 for apple juice, i = 8 for grape juice, and i = 9 for other food commodities; N is the total U.S. population; y is total U.S. personal consumption expenditures on food; and Z is a vector of socioeconomic characteristics indicating preferences. Maximization of utility subject to the budget constraint yields per capita demand equations $q_i/N = f_i(p_1/p_9, \ldots, p_8/p_9, y/(p_9N), Z)$ where prices and expenditures on food are expressed relative to $p_9$ --- the price of other food commodities approximated in this study by the implicit price deflator for food --- invoking the property that demand equations are homogeneous of degree zero in prices and income or total food expenditures, in the present case. Utility maximization as set forth here can be thought of as part of the following stage of a two-stage budgeting process. In the first stage total income is allocated to broad commodity groups, food being one such group, while in the second stage income allocated to each group is spent on individual commodities within the group.

In this study, the per capita demand equations were specified in double logarithmic form. The double logarithmic specification is considered only as an approximation to the true functional form (Deaton and Muellbauer, 1980; Johnson and Safyurtlu, 1984). However, this form appears to adequately describe the demands for citrus juice products, as others have found (Ward and Tilley, 1980; Tilley, 1979; Ward and Davis, 1978). Alternative specifications -- linear, semilogarithmic, logit, and

almost ideal demand system -- were also explored but provided little or no improvement in fit and generally provided less reasonable forecasts in comparison to the double logarithmic specifications.

The Z vector in the per capita specifications is used to capture variations in consumer behavior over seasons of the year and time. Specifically, Z is composed of seven variables: five bimonthly dummy variables; a dummy variable for recent orange juice promotional programs by Proctor and Gamble Company, Coca-Cola Company and Beatrice Companies, Inc. (FDOC advertising expenditures were relatively constant in real terms over the years analyzed and were excluded from the model); and the percent of the female population in the labor force.

The double logarithmic per capita demand specification for the $i^{th}$ juice can be written as

$$\log(q_i/N) = \alpha_{i1} + \sum_{j=2}^{6} \alpha_{ij} S_j + \alpha_{i7} A + \alpha_{i8} \log F + \sum_{k=1}^{8} \beta_{ik} \log(p_k/p_9) + \beta_{i9} \log(y/(p_9 N)) + \varepsilon_i$$

where the $\alpha_{ij}$'s and $\beta_{ik}$'s are parameters to be estimated (demand elasticities in the case of $\alpha_{i8}$ and the $\beta_{ik}$'s), the $S_j$'s are bimonthly dummy variables ($S_j$ = 1 if the $j^{th}$ bimonthly period, 0 otherwise), A is a dummy variable for recent promotional activities (A = 1 after September 1983, 0 otherwise), F is the percent of the female population in the labor force, and $\varepsilon_i$ is a disturbance term. The latter can be rationalized as a composite measure of the many other citrus juice demand factors, some of which have been discussed earlier in the second section of this paper.

## Data and Variables

Data used in this study were from A.C. Nielsen Marketing Research; NPD Research, Inc.; the U.S. Department of Commerce, Bureau of Census (1984a, 1984b); the U.S. Department of Commerce, Bureau of Economic Analysis; and the U.S. Department of Labor, Bureau of Labor Statistics. A.C. Nielsen provided bimonthly total U.S. dollar and gallon sales for FCOJ, COJ, CSSOJ, FCGJ, CGJ, and CSSGJ. NPD provided data from which bimonthly total U.S. prices for apple and grape juice were derived. The U.S. Department of Commerce, Bureau of Economic Analysis was the source for U.S. personal consumption expenditures on food and the implicit price deflator for food (CPIF, 1972=100). The U.S. Department of Commerce, Bureau of Census (1984b) and the U.S. Department of Labor, Bureau of Labor Statistics provided data on the percent of the female population in the labor force, and the U.S. Department of Commerce, Bureau of Census (1984a) was the source for the U.S. population and the population projections used to expand the per capita forecasts to total U.S. forecasts.

The data were complete from 1978-I (the first bimonthly period for 1978 running from December 1977 through January 1978) to 1984-III (the third bimonthly period for 1984 running from May through June 1984), providing 39 bimonthly observations. The notation for a bimonthly period in a year is year dash the appropriate Roman numeral for the bimonth.

The different data were used to construct the variables employed in this study as indicated below.

1. The per capita quantities (q/N's) for FCOJ, COJ, CSSOJ, FCGJ, CGJ, and CSSGJ are total U.S. retail quantities sold divided by population and are measured in single strength equivalent (SSE) gallons per 1,000 persons per two months.
2. The per capita real food expenditure variable ($y/(p_g N)$) is nominal U.S. personal consumption expenditures on food divided by population divided by the implicit price deflator for food, the CPIF, and is measured in real dollars per person per year.
3. The real prices ($p_i/p_g$'s) for FCOJ, COJ, CSSOJ, FCGJ, CGJ, and CSSGJ are dollar sales divided by gallon sales divided by the CPIF. The real prices for apple and grape juice are cents per reconstituted quart divided by the CPIF.
4. The five seasonal variables are bimonthly dummies, i.e., $S_2 = 1$ if in the second bimonthly period, 0 otherwise; ...; $S_6 = 1$ if in the sixth bimonthly period, 0 otherwise.
5. The advertising variable (A) for recent promotional campaigns by Proctor and Gamble Company, Beatrice Companies, and Coca-Cola Company takes a value of 1 after September 1983, 0 otherwise.
6. The percent of the female population in the labor force was used directly as reported in the U.S. Department of Commerce, Bureau of Census (1984b) and the U.S. Department of Labor, Bureau of Labor Statistics.

## Results

The double logarithmic demand equations were estimated by ordinary least squares. The results are reported in Appendix A. Although all fit well, the coefficients of determination ranging from .81 for FCGJ to .98 for COJ, CSSOJ, and CSSGJ, the simple correlations between explanatory variables and the eigenvalues of the cross product matrix (explanatory variables scaled to unit length but not centered) suggest multicollinearity may be a problem. To alleviate this problem, prior information on the income and price elasticities was employed along with the sample data, and the demand equations were reestimated using the mixed estimation procedure (Theil and Goldberger, 1961; Theil, 1971; Belsley et al, 1980).

The prior information used in the mixed estimation procedure consists of stochastic linear restrictions on the demand coefficients derived from a number of sources (Ward and Tilley, 1980; Lamm, 1982;

Johnson and Safyurtlu, 1984; and previous research by the authors). Appendix B summarizes this information. The prior point estimates of the food expenditure elasticities ranged from 2.5 for COJ to .5 for CSSGJ. The variances for these point estimates were all assumed to be 1.04, implying reasonable 95% confidence intervals of ±2 around the point estimates. Based largely on Ward and Tilley's (1980) findings and similarities between orange and grapefruit juice products, the prior point estimates and variances for the own price elasticities were -1.35 and .47, respectively, for FCOJ, CSSOJ, FCGJ, and CSSGJ; and -.90 and .21, respectively, for COJ and CGJ. The 95% confidence intervals for the -1.35 and -.90 elasticity point estimates are 0 to -2.70 and 0 to -1.80, respectively. The prior point estimates of all cross price elasticities were zero, each with a variance of .26, implying 95% confidence intervals of -1 to 1.

The prior information on price and income elasticities was combined with the sample data and the mixed estimation procedure was used to reestimate the citrus juice demand equations. The mixed estimation parameter estimates with standard error estimates and compatibility statistics are reported in Appendix C. The compatibility statistic for each demand equation indicates that the prior and sample information are in agreement at the .10 level. That is, overall the prior point elasticity estimates do not significantly deviate from the OLS counterparts based on the sample data. Also, as anticipated, the mixed estimation variance estimates for the demand coefficients are smaller than their OLS counterparts, as revealed in Appendices A and C.

Based on the mixed estimation results in Appendix C and generally supported by the OLS results in Appendix A as expected given the compatibility results, a number of demand relationships can be identified. First, the percent of females in the labor force appears to positively influence the demands for chilled ready-to-serve citrus juices, COJ and CGJ, while negatively or insignificantly influencing the other demands. Overall, these results perhaps indicate a preference for convenience. Second, the coefficient estimates for the advertising dummy, significantly positive for COJ and negative or insignificant for the other products, suggest that recent advertising by national firms has been successful in increasing the demand for COJ, its principle target, but possibly at the expense of some product switching. Third, as indicated by the bimonthly dummy variable coefficient estimates, the citrus juice demands generally appear to vary over the seasons of the year (as expected, the FCOJ and COJ demands tend to peak in opposite seasons, winter and summer, respectively). Fourth, with the addition of prior information on the food expenditure elasticities, the per capita food expenditure variable positively influences all citrus juice demands, although only the results for COJ and CSSOJ are significant. COJ has the highest food expenditure elasticity at 1.4. Fifth, consistent with theory, the own price coefficient or elasticity estimates are all negative and, except for FCOJ, significant. Based on these results, the demands for COJ, CSSOJ, and CGJ are elastic while the demands for FCOJ, FCGJ, and CSSGJ are inelastic. Finally, the cross price coefficient estimates, mixed in sign and significance, suggest a number of possible substitute, complementary, and neutral relationships.

The mixed estimation and OLS coefficient estimates along with assumed values for the explanatory variables were used to forecast citrus juice demands in 1985, 1990, 1995, and 2000. Per capita bimonthly forecasts for each of these years were first calculated. Then, total yearly U.S. forecasts were obtained by multiplying the bimonthly forecasts by the projected population, reported by the U.S. Department of Commerce, Bureau of Census (1984a), and summing over the bimonthly periods of each year. In Table 6, the total yearly U.S. forecasts are reported along with 1983 actual quantities for comparison.

As indicated by the footnote of Table 6, the forecasts are dependent on the settings of the explanatory variables. The prices for the forecasts in Table 6 have been set at levels consistent with expected growth in orange and grapefruit supplies. In 1985, supplies should still be relatively small as a result of the December 1983 freeze, and real prices should be near the levels existing in 1984-III. In 1990 and 1995, supplies should increase as growers recover from the freeze, and real prices are expected to fall to levels before the freeze. (Another possibility is that real prices may even fall below pre-freeze levels, largely depending on the growth in the Brazilian citrus industry and their exports to the United States).

As anticipated, based on the compatibility of the prior and sample information, both the OLS and mixed estimation forecasts reported in Table 6 indicate similar citrus juice demand patterns in the coming years. Given the explanatory variable assumptions (as stated in Table 6's footnote), orange juice demand in total is forecasted to grow by about 3% per year while grapefruit juice demand in total is forecasted to grow by about 1% per year. As reported in the last column of Table 6, for the individual citrus juice product types, annual demand growth rates are expected to be slightly less than 2% for FCOJ, about 4% to 4.5% for COJ, slightly less than 1% for CSSOJ, about 1.5% for FCGJ, over 3% for CGJ, and roughly -1% for CSSGJ. The relatively high growth rates for the ready-to-serve product forms, COJ and CGJ, reflect changing consumer preferences for convenience and growing real per capita income. The forecasted negative growth rate for CSSGJ reflects a general decline in sales of this product in recent years.

Finally, as with most economic forecasts, it should be noted that the forecasts of this study are inherently subject to imprecision. The imprecision arises not only from the randomness of the independent variables being forecasted and the estimated parameters employed but also from the uncertainty regarding the levels of many of the explanatory variables themselves. Moreover, given the ever changing nature of the world, structural changes resulting perhaps from consumer preference shifts and/or product development may alter the estimated demand relationships employed in this study.

Table 6
U.S. Retail Orange and Grapefruit Juice Demands in Millions of Single Strength Gallons

| Product | | Actual | Forecast[a] | | | | | | | | Annual Growth Rate 1985-2000 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1985 | | 1990 | | 1995 | | 2000 | | | |
| | | 1983 | OLS | Mixed | OLS | Mixed | OLS | Mixed | OLS | Mixed | OLS | Mixed |
| | | million SS gallons | | | | | | | | | percent | |
| Orange Juice | FCOJ | 494 | 457 | 459 | 544 | 549 | 570 | 580 | 591 | 606 | 1.7 | 1.9 |
| | COJ | 346 | 396 | 396 | 536 | 566 | 624 | 677 | 705 | 786 | 3.9 | 4.7 |
| | CSSOJ | 23 | 20 | 20 | 22 | 21 | 22 | 22 | 23 | 22 | .9 | .6 |
| | Total | 863 | 873 | 875 | 1102 | 1136 | 1216 | 1279 | 1319 | 1414 | 2.8 | 3.3 |
| Grapefruit Juice | FCGJ | 14 | 14 | 14 | 15 | 16 | 16 | 17 | 17 | 18 | 1.3 | 1.7 |
| | CGJ | 28 | 30 | 30 | 38 | 37 | 44 | 43 | 50 | 48 | 3.5 | 3.2 |
| | CSSGJ | 47 | 37 | 37 | 35 | 35 | 32 | 32 | 31 | 31 | -1.2 | -1.2 |
| | Total | 89 | 81 | 81 | 88 | 88 | 92 | 92 | 98 | 97 | 1.3 | 1.2 |

[a]The 1985 forecasts are based on real prices existing after the December 1983 freeze, in 1984-III, the most recently observed period; the 1990, 1995, and 2000 forecasts are based on prices existing just before the freeze in 1983-VI; real per capita food expenditures, beginning at about the 1984-III level for 1985, were increased by 4% every 5 years, a growth rate consistent with past increases in food expenditures; the percent of females in the labor force was set at 54.1 in 1985, 56.4 in 1990, 57.9 in 1995, and 59.0 in 2000, based on projections by Fullerton (1980); and the advertising dummy variable was given a value of 1, reflecting the most recent promotional effects.

## Summary

Based on the demand relationships found in this study and expected price levels and growth in population, food expenditures, and the female labor participation rate, in coming years the total demand for orange juice should increase substantially with a growth rate of about 3% per year. On the other hand, grapefruit juice demand in total should grow at a substantially lesser rate, about 1% per year. Of the different forms of orange juice, COJ should experience the greatest demand growth, with FCOJ demand growing at a more moderate rate and CSSOJ demand flattening out. Of the different forms of grapefruit juice, CGJ should experience the greatest demand growth with FCGJ demand growing more moderately and CSSGJ demand possibly decreasing. The relatively high growth rates for the ready-to-serve product forms, COJ and CGJ, reflect the expected increase in preferences for convenience and the expected growth in real per capita food expenditures.

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Appendix A. Double Logarithmic Per Capita Demand Ordinary Least Squares Estimates for Orange and Grapefruit Juice Products, Based on the Period from 1978-I to 1984-III[a]

| Independent Variable | Coefficient Estimates[b] | | | | | |
|---|---|---|---|---|---|---|
| | Orange Juice | | | Grapefruit Juice | | |
| | FCOJ | COJ | CSSOJ | FCGJ | CGJ | CSSGJ |
| Intercept | 4.488 | -9.598 | 4.071 | -1.849 | -10.493 | 21.548 |
| | (4.342) | (7.970) | (4.477) | (8.391) | (7.168) | (7.193) |
| Log of the Percent of Females in the Labor Force | .499 | 2.289 | -1.895 | 1.193 | 3.141 | -4.339 |
| | (.530) | (.972) | (.546) | (1.024) | (.875) | (.878) |
| Advertising | .003 | .112 | -.020 | -.086 | .005 | -.074 |
| | (.023) | (.042) | (.023) | (.044) | (.037) | (.038) |
| Bimonth 2 | -.005 | .023 | .051 | .066 | .094 | .115 |
| | (.012) | (.023) | (.013) | (.024) | (.020) | (.020) |
| 3 | -.025 | .027 | .043 | .079 | .155 | .082 |
| | (.016) | (.030) | (.017) | (.031) | (.027) | (.027) |
| 4 | -.073 | .036 | .038 | .059 | .184 | .032 |
| | (.020) | (.036) | (.020) | (.038) | (.033) | (.033) |
| 5 | -.048 | .063 | .047 | .101 | .200 | .048 |
| | (.020) | (.037) | (.021) | (.039) | (.033) | (.033) |
| 6 | .003 | .027 | .050 | .113 | .139 | .067 |
| | (.019) | (.035) | (.019) | (.037) | (.031) | (.031) |
| Log of Real Per Capita Food Expenditures | -.145 | .931 | .808 | -.289 | .540 | -.158 |
| | (.508) | (.933) | (.524) | (.982) | (.839) | (.842) |
| Log of Real Price of FCOJ | .036 | .754 | -.157 | -1.001 | -1.502 | -1.412 |
| | (.388) | (.713) | (.400) | (.751) | (.641) | (.643) |
| COJ | -.510 | -2.553 | .394 | 2.357 | 3.326 | 2.435 |
| | (.630) | (1.157) | (.650) | (1.218) | (1.041) | (1.044) |
| CSSOJ | -.801 | .079 | -1.237 | -.910 | -1.619 | -.263 |
| | (.269) | (.495) | (.278) | (.521) | (.445) | (.446) |
| FCGJ | -.085 | .187 | .550 | -1.418 | -.139 | -.152 |
| | (.286) | (.524) | (.294) | (.552) | (.471) | (.473) |
| CGJ | .016 | .466 | -1.071 | .102 | -1.083 | -.581 |
| | (.268) | (.492) | (.277) | (.518) | (.443) | (.444) |
| CSSGJ | .249 | .259 | .099 | .693 | .114 | -.717 |
| | (.170) | (.312) | (.175) | (.329) | (.281) | (.282) |
| Apple Juice | .344 | -.615 | .488 | .200 | -.533 | .108 |
| | (.286) | (.526) | (.295) | (.553) | (.473) | (.474) |
| Grape Juice | -.104 | .101 | -.011 | .024 | .010 | -.064 |
| | (.090) | (.166) | (.093) | (.174) | (.149) | (.149) |
| Coefficient of Determination | .93 | .98 | .98 | .81 | .92 | .98 |

[a]The sample consisted of 39 observations.

[b]Estimated standard errors are given in parentheses.

Appendix B. Prior Information: Prior Point Estimates of Coefficients or Elasticities of the Double Logarithmic Citrus Juice Demand Equation and Variances[a]

| Independent Variable | | Orange Juice | | | Grapefruit Juice | | |
|---|---|---|---|---|---|---|---|
| | | FCOJ | COJ | CSSOJ | FCGJ | CGJ | CSSGJ |
| Log of Real Per Capita Food Expenditures | | 2[b] (1.04)[c] | 2.5 (1.04) | 1.5 (1.04) | 1 (1.04) | 1.5 (1.04) | .5 (1.04) |
| Log of Real Price of | FCOJ | -1.35 (.47) | 0 (.26) | 0 (.26) | 0 (.26) | 0 (.26) | 0 (.26) |
| | COJ | 0 (.26) | -.90 (.21) | 0 (.26) | 0 (.26) | 0 (.26) | 0 (.26) |
| | CSSOJ | 0 (.26) | 0 (.26) | -1.35 (.47) | 0 (.26) | 0 (.26) | 0 (.26) |
| | FCGJ | 0 (.26) | 0 (.26) | 0 (.26) | -1.35 (.47) | 0 (.26) | 0 (.26) |
| | CGJ | 0 (.26) | 0 (.26) | 0 (.26) | 0 (.26) | -.90 (.21) | 0 (.26) |
| | CSSGJ | 0 (.26) | 0 (.26) | 0 (.26) | 0 (.26) | 0 (.26) | -1.35 (.47) |
| | Apple Juice | 0 (.26) | 0 (.26) | 0 (.26) | 0 (.26) | 0 (.26) | 0 (.26) |
| | Grape Juice | 0 (.26) | 0 (.26) | 0 (.26) | 0 (.26) | 0 (.26) | 0 (.26) |

[a]Prior point estimates are assumed to be independent with zero convariances.

[b]Elasticity Estimate.

[c]Variance.

Appendix C. Double Logarithmic Per Capita Demand Mixed-Estimation Estimates for Orange and Grapefruit Products, Based on the Period from 1978-I to 1984-III[a]

| Independent Variable | Coefficient Estimates[b] | | | | | |
|---|---|---|---|---|---|---|
| | Orange Juice | | | Grapefruit Juice | | |
| | FCOJ | COJ | CSSOJ | FCGJ | CGJ | CSSGJ |
| Intercept | 3.714 | -14.289 | 6.302 | -6.080 | -12.341 | 19.782 |
| | (3.390) | (4.760) | (3.460) | (5.001) | (4.458) | (4.559) |
| Log of the Percent of Females in the Labor Force | .321 | 3.256 | -2.281 | 1.073 | 2.809 | -4.495 |
| | (.454) | (.701) | (.467) | (.740) | (.645) | (.658) |
| Advertising | .007 | .141 | -.029 | -.129 | -.040 | -.116 |
| | (.021) | (.035) | (.021) | (.037) | (.032) | (.033) |
| Bimonth 2 | -.004 | .033 | .049 | .060 | .086 | .109 |
| | (.012) | (.022) | (.012) | (.023) | (.020) | (.020) |
| 3 | -.031 | .031 | .039 | .085 | .157 | .092 |
| | (.015) | (.024) | (.015) | (.026) | (.022) | (.022) |
| 4 | -.081 | .033 | .033 | .077 | .197 | .054 |
| | (.017) | (.027) | (.017) | (.028) | (.025) | (.025) |
| 5 | -.057 | .054 | .043 | .125 | .221 | .075 |
| | (.017) | (.026) | (.017) | (.028) | (.024) | (.024) |
| 6 | -.011 | .026 | .045 | .120 | .157 | .084 |
| | (.016) | (.027) | (.017) | (.028) | (.025) | (.025) |
| Log of Real Per Capita Food Expenditures | .171 | 1.420 | .708 | .393 | .697 | .100 |
| | (.411) | (.592) | (.420) | (.615) | (.557) | (.564) |
| Log of Real Price of FCOJ | -.323 | .061 | -.104 | -.051 | -.190 | -.296 |
| | (.247) | (.285) | (.239) | (.298) | (.284) | (.285) |
| COJ | -.065 | -1.286 | .316 | .466 | .576 | .545 |
| | (.364) | (.376) | (.357) | (.407) | (.397) | (.398) |
| CSSOJ | -.685 | -.186 | -1.224 | -.351 | -.761 | -.0001 |
| | (.227) | (.325) | (.243) | (.335) | (.310) | (.311) |
| FCGJ | .005 | .230 | .376 | -.917 | .193 | .048 |
| | (.213) | (.285) | (.217) | (.314) | (.269) | (.279) |
| CGJ | -.037 | .371 | -.888 | -.256 | -1.276 | -.688 |
| | (.203) | (.279) | (.206) | (.297) | (.257) | (.268) |
| CSSGJ | .123 | .028 | .196 | .687 | .379 | -.554 |
| | (.132) | (.183) | (.135) | (.198) | (.173) | (.179) |
| Apple Juice | .104 | -.707 | .458 | .358 | .112 | .433 |
| | (.219) | (.317) | (.223) | (.327) | (.300) | .301 |
| Grape Juice | -.042 | .155 | -.013 | .005 | -.034 | -.134 |
| | (.085) | (.145) | (.087) | (.152) | (.133) | (.133) |
| Compatibility Statistic[c] | 9.306 | 7.376 | 6.489 | 8.346 | 14.108 | 9.759 |

[a]The sample data of 39 observations were combined with nine prior stochastic linear restrictions.

[b]Estimated standard errors are given in parentheses.

[c]Under the null hypothesis that the sample and prior information are not in conflict, the compatibility statistic asymptotically has a chi-square distribution with nine degrees of freedom in the present case (Theil).