A Matrix of Demand Elasticities for Fresh Fruit

David W. Price and Ronald C. Mittelhammer

A matrix of direct, cross and income demand elasticities at farm level for 14 fresh fruits was estimated using the mixed estimation technique. Prior estimates were derived from past research and application of the symmetry relation, cross induction and subjective judgment. There were no statistically significant conflicts between the sample and prior information. Even though estimation efficiency increased with the mixed technique, only a limited number of cross elasticities could be estimated.

Researchers have long recognized that cross elasticities of demand among food commodities of similar tastes and uses are important for policy purposes. Brandow and George and King have estimated matrices of demand elasticities for many agricultural commodities by using restrictions derived from economic theory. In spite of the relatively large number of commodities estimated by George and King (49 items) only three fresh fruits — apples, bananas and oranges — were included. Brandow's matrix had even less detail.

The purpose of this study is to estimate a demand matrix at the farm level for 14 fruits sold for fresh use.[1] The estimates were made by using the Theil-Goldberger mixed-estimation technique. This technique combines sample with prior information and can result in more efficient estimates than the use of sample information alone. Prior estimates were derived from the results of previous studies, use of the symmetry relationships, and the device of assigning similar estimates to commodities with similar characteristics.

Methodological Issues

Direct empirical estimation of reliable cross elasticities with time series data has been difficult. Multicollinearity and few degrees of freedom have resulted in coefficients with either wrong signs or large standard errors. As an example, most studies of the demand for apples include no substitutes [Pasour]. Yet many agricultural economists believe that grapes, oranges, pears and bananas are important substitutes for apples.

In previous studies estimation of cross elasticities in large demand matrices has required the use of the symmetry relationship, the homogeneity condition, the Cournot Aggregation, the Engel Aggregation and the Frisch Equations [George and King, pp. 39-40]. These conditions are derived under the usual assumptions of neoclassical demand theory and are subject to its usual limitations. These conditions have been derived for the individual consumer at the retail level. It can

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[1]Fresh fruit is defined as that going through marketing channels in the fresh form. The quantity data distinguished between that going fresh and that going to the commercial processing outlet for all fruits with substantial processing outlets. Some fresh fruits may be consumed in the processing form because of home processing.

be shown that the Engel Aggregation and the Cournot Aggregations generally apply at the market level (for a concise presentation of the applicability of these conditions at the market level see Mittelhammer, pp. 74-86). If income changes are distributed proportionately among households, the homogeneity conditions also apply. The symmetry conditions are approximately valid if the marginal propensities to consume the commodities in question are similar or show little variation among households.

The Frisch Equations are derived under the assumption of want independence. As George and King point out (p. 34), it is not appropriate to use the want independent assumption for groups of closely related commodities.[2] Therefore, these equations are of little use in constructing a matrix of demand coefficients for fresh fruits.

With the Theil-Goldberger mixed-estimation technique, prior knowledge of the size and standard errors of the coefficients can be combined with sample information to yield estimates of model parameters. The mixed-estimation estimates are more efficient than estimates not using prior information when the prior information is unbiased [Theil and Goldberger, p. 67].[3]

Prior estimates of elasticities were derived with the use of the symmetry relationships. These relationships are not strictly applicable here since the marginal propensities to consume the various fruits are not expected to be equal among households. However, the mixed-estimation technique enables one to place confidence limits on the prior estimates. The method for assigning these limits will be given in the section on prior information. Prior information which is only approximate can be entered as uncertain information. Statistical procedures are available to assess the compatibility of prior and sample information and to measure the proportion of the final estimates attributable to the prior information.

The Model

Data limitations dictated that the model be estimated with farm level prices for fruits sold for fresh use. Retail price series are available for only a few fresh fruits. The model hypothesizes prices to be a function of quantities sold, income and prices of substitute fruits,

$$(1) \qquad P_i = P_i\,(Q_i,\ I,\ P_\ell, \ldots,\ P_k)$$

where there are k substitutes and $\ell \neq 1,\ldots,k$, n commodities, $i = 1,\ldots, n$, I represents income, quantities and income are on an adult equivalent basis, and prices and income are deflated.

Income and quantities sold were assumed to be exogenous. Prices were assumed to be endogenous. Income may be assumed exogenous if income generated from the fresh fruit sector is not highly correlated with income generated in the overall economy. Much of the variation in income generated by the fruit sector can be attributed to freezes which would not logically be related to variations in national income.

Conceptually fresh quantity can be responsive to price and thus considered an endogenous variable since total quantity can be diverted between fresh and processing. In practice diversion between fresh and processing is restricted by various factors. Fruit varieties suitable for fresh use frequently differ from those suitable for processing. Cultural practices of growing fruit differ for these forms. Growers tend to be traditional in their selection of outlets for their fruit. In some areas lack of processing facilities inhibits diversion. Thus, although some diversion between fresh and processing may occur in response to price, the effect on the estimates of the coefficients from assuming fresh quan-

[2]The George and King procedure involved grouping commodities and estimating cross elasticities within groups by empirical estimation and between groups with the Frisch equations.

[3]More specifically it can be shown that $\frac{\text{var } b_i^*}{\text{var } b_i} \leq 1$ for all i where b_i^* is an OLS-mixed estimation coefficient, and b_i is a pure OLS estimate.

tities to be exogenous should be slight [Christ, pp. 473-481].

The formulation in equation 1 is a slightly modified version of the usual theoretical equation where the quantity consumed is a function of prices and income. The only difference in equation 1 is that quantity is shifted to the right-hand side and commodity price to the left. Hence, direct price, income and cross elasticities of demand cannot be estimated directly from this equation. Another alternative is to place price on the left-hand side and all quantities on the right. The formulation expressed by equation 1 is preferred for the following reasons. The quantity purchased by consumers of a particular fruit is directly influenced by prices of substitutes. Since quantities are influenced much less than prices by the endogenous variables in the model, the primary vehicle for market clearing is price variation. Prices of substitutes, therefore, directly affect the price of the commodity under study. Quantities of substitutes indirectly affect the price of the commodity under study through their prices.

It is impossible to include all fresh fruit substitutes for a given fruit even with the mixed-estimation technique. If a large number of substitutes is included, multicollinearity and few degrees of freedom lead to the usual problems of imprecise estimates. Even though efficiency is improved with mixed estimation, imprecision can persist if too many substitutes are included. Therefore, only the substitutes with similar marketing periods, and taste and texture characteristics of the fruit were included in each regression. For example, the substitutes for apples included oranges, bananas and grapes. The substitutes for peaches included plums, grapes, cantaloupe and watermelon.

Annual observations were used from the 25-year period 1949-73. Price data were obtained from the SRS series published in various supplements to agricultural prices. Quantity data were obtained from the SRS series *Production, Use Value*. Import and export data were obtained from *U.S. Foreign Agricultural Trade*. All prices and incomes were deflated by the consumer price index. Quantities were placed on an adult equivalent basis with scales estimated by Price (1970) for all fruit. Prices were either packinghouse door, first delivery point or the actual price received by growers, except for bananas which were priced at the point of import. A first difference of logs was used as the functional form in order to provide consistency with the specification used by George and King.

The Prior Information

The prior information was specified as demand elasticities which were then transformed into coefficients as specified in equation 1. This transformation is explained later.

Farm level estimates by George and King (pp. 64-66) were used for the prior direct price elasticities for fresh apples and oranges. The income elasticities of retail demand for fresh apples and oranges were used as approximations since George and King did not compute farm level income elasticities. The farm level income and direct price elasticities estimated by Price (1968) were used as prior estimates for sweet cherries. Fruits with seasonal production and other characteristics similar to sweet cherries were given similar direct price and income elasticities, as were fruits having characteristics resembling apples and oranges (Table 1). Sweet cherries are relatively high priced, have a short season, and have relatively small quantities sold. In contrast, apples and oranges are relatively low priced, have a long season, and relatively large quantities are sold. One would expect sweet cherries and strawberries to have the most elastic demand and highest income elasticities of all these fresh fruits, and apples and oranges to have the lowest demand and income elasticities. Thus, apples and oranges established one benchmark and sweet cherries the other. Other fruits between the two benchmarks were assigned elasticities corresponding with their characteristics. One could have relied on previous studies to obtain direct price and income elasticities for fruits other than apples, oranges and sweet

TABLE 1. Prior Demand Elasticities

	Apples	Pears	Oranges	Tange-rines	Grape-fruit	Peaches	Canta-loupe	Water-melon	Plums	Prunes & Plums	Grapes	Nectar-ines	Sweet Cherries	Straw-berries	Bananas	Income
Apples	−.700	.090	.180								.050				.120	.140
Pears	.700	−1.500	.250								.078				.200	.135
Oranges	.150		−.500	.060	.080						.050				.050	.260
Tangerines	.319		.700	−1.500	.080						.070				.204	.260
Grapefruit			.250		−.500										.050	.260
Peaches						−1.500	.375	.150	.090		.250					.400
Cantaloupe						.500	−1.500	.450	.090		.250					.400
Watermelon						.260	.600	−1.500	.060		.090					.100
Plums						.600	.460	.150	−1.800	.320	.300					.400
Prunes & Plums						.600	.460	.150	.800	−1.800	.300					.125
Grapes	.250		.180			.500	.380	.100	.090		−1.500				.120	.400
Nectarines						.800	.400	.200			.300	−2.00				.400
Sweet Cherries													−.2398	1.278		.600
Strawberries													.180	−2.398		.400

[a]Plums produced in California

[b]Mostly prices produced in Michigan, Idaho, Washington and Oregon

cherries. However, elasticities in these studies may not be comparable among fruits, because they are derived from different time periods. This benchmark method allows consistency among the various fruits.

The cross elasticities estimated by George and King were used as the prior estimates for apples, oranges and bananas. They also provided a benchmark for assigning prior estimates of other cross elasticities. Two other devices were used to obtain prior estimates of cross elasticities. The following symmetry relation was imposed on all prior cross elasticities,

$$(2) \qquad e_{ij} = \frac{w_j}{w_i} e_{ji} + w_j (e_{jy} - e_{iy})$$

where e_{ij}'s are cross elasticities for quantity i, price j, e_{iy}'s are income elasticities for quantity i and income , and w_i's are expenditure weights.

Second, where commodities were assumed to be equivalent in taste and functional characteristics, the cross elasticities were assigned in proportion to the expenditure weights. If the income effect is minor, this method of weighting is consistent with the symmetry relationship. It has intuitive appeal because price relationships between major and minor fruits are dominated by major fruits. For example, oranges are a much more important substitute for apples than are tangerines.

The use of the symmetry relationship for farm level demands requires justification. Assuming that the elasticities of price transmission, defined as the percentage change in retail price with respect to a percentage change in farm prices, are equal across the commodities in question and that the net effect of income in (2) is negligible, the symmetry conditions that hold at the retail level will also be valid at the derived level of demand. This condition is expressed as

$$(3) \qquad w_i \frac{\partial Q_i}{\partial P^f_j} \frac{P^f_j}{Q_i} = w_j \frac{\partial Q_j}{\partial P^j_i} \frac{P^f_i}{Q_j}$$

where P^f_i refers to the farm level price of commodity i. This result follows from the fact that

$$(4) \qquad \frac{\partial Q_i}{\partial P^f_j} \frac{P^f_j}{Q_i} = e_{ij}\, n_j$$

where n_j is the elasticity of price transmission between retail and farm price for the j^{th} commodity. If $n_j = n_i$, then

$$(5) \qquad w_i\, e_{ij}\, n_j = w_j\, e_{ij}\, n_i$$

is implied by the symmetry condition (2), assuming negligibility of the income effects.

For all fresh fruits the "income" effect is expected to be extremely small. The elasticities of price transmission may not be exactly equal between all pairs of fresh fruits showing cross elasticities in the prior estimates (Table 1). However, since all of these fruits do not change form from the farm gate to the retail level, and since they all go through similar marketing channels it is assumed that the elasticities of price transmission do not differ substantially. The symmetry conditions are applied at the farm level with the realization that the test of compatibility between sample and prior information will indicate the reasonableness of the symmetry conditions.

Cross elasticities between other fruits and apples were assigned in proportion to their expenditure weights. For example, a fruit with half the expenditure weight of oranges would be assigned half the cross elasticity of oranges. This process utilizes the expenditure weight concept inherent in the symmetry relationship, but not the symmetry relationship itself. This process continued until the row of substitutes for apples was completed. The next step used the symmetry relation to compute the cross elasticity of apples with the substitutes for apples. This process continued until the cross elasticity matrix shown in Table 1 was completed. Cross elasticities were increased where subjective judgment indicated that fruits were close substitutes. Extremely small values of the computed prior cross elasticities (i.e. less than .05) were set equal to zero (Table 1). Inclusion of variables to measure these small effects lowers the degrees of freedom and likely results in multicollinearity, thereby making it difficult to obtain reliable estimates of other coefficients.

Elasticities were transformed to the form specified in equation 1 by interchanging price and quantity and dividing through by the direct price elasticity. The log form of equation 1 is:[4]

$$(6)\quad \log P_i = a + b_i \log Q_i + \sum_{j \neq i}^{k} b_j \log P_j + b_I \log I.$$

Transforming gives:

$$\log Q_i = \frac{a}{b_i} + \frac{1}{b_i} \log P - \frac{1}{b_i} \sum_{j \neq i}^{k} b_i \log P_j - \frac{1}{b_i} \log I.$$

[4]In order to complete the system a demand equation for bananas was estimated by mixed estimation. It was

$$\underset{}{P_B} = \underset{(.48)}{-.0123} - \underset{(.139)}{.444Q_B} + \underset{(1.16)}{.070P_G} + \underset{(.91)}{.149P_A}$$

Where P_B = 1st difference of the log of the deflated price of bananas; Q_B = 1st difference of the log of the per adult equivalent quantity of bananas; P_G = 1st difference of the log of the deflated price of grapes; and P_A = 1st difference of the log of the deflated price of apples (t values are in parentheses).

The direct price and the income elasticities were the mean of the prior for apples and oranges. The prior cross elasticities were derived from the other prior cross elasticities by the symmetry relation. Oranges were included in the first run but excluded from the final run because of wrong sign and non significant t.

The elastic demand for bananas contrasts with the demand characteristics for either oranges or apples. Due to the low mixed R^2 value of .02, and the relatively low t values, the banana equation should be considered only as a means of completing the system of equations. Little validity can be given the coefficients themselves. Hopefully they are reliable enough, to derive the reduced form for the other fruits.

For mixed estimation, the variance-covariance matrix of the prior estimates must be specified [Theil, p. 259]. Covariance elements were assumed to be zero, which implies that errors in the prior estimate of one coefficient have no effect on errors in the prior estimates of all other coefficients. It is extremely difficult to specify these covariance elements. Errors in the prior estimates can stem from errors in the benchmark coefficients and from empirical characteristics of specific fruits, particularly substitutability of fruits since the prior estimates largely depend on consistency in substitution among fruits. The latter errors would likely have covariance elements near zero implying that errors for a particular coefficient would not affect the prior estimates of another coefficient. Judge, Yancey and Bock (p. 31) state that "This covariance may for example reflect additional information from a previous sample and hence Ω (the variance - covariance matrix of prior estimates) is $s^2 (X_0 'X_0)^{-1}$ from that sample. Alternatively the covariance may reflect subjective prior information and a plausible Ω is a diagonal matrix with known elements reflecting the relative sizes of the specified variances." Covariance elements are not reported by George and King. Therefore, without this knowledge and with the high probability of independent errors, covariance elements were set equal to zero.

The standard errors of the prior estimates of the direct price coefficients (double log form of equation 1) were set equal to one-half the size of the coefficient. Assuming normally distributed errors in the prior information, a 95 percent confidence interval would roughly encompass the interval from zero to double the elasticity value. The prior information about cross and income coefficients was considered less certain. Almost all models of fruit demand show much higher estimation errors for these coefficients. Therefore, high errors in the benchmark coefficients would be expected. The standard errors of these elasticities were set equal to the sizes of the respective coefficients. Thus, a 95 percent confidence interval includes a small interval where the coefficient had a sign opposite to that hypothesized by the prior point estimate.

Results

The log form of equation 1 (equation 6) was estimated by mixed two-stage least squares for all fruits having substitutes.[5] The first run included all substitutes and income with prior point estimates greater than zero (Table 1). Retaining prices of all substitute fruits in some equations caused multicollinearity. When severe, multicollinearity results in the prior information dominating sample information in the mixed estimates. Variables were generally dropped if t values with mixed estimation were less than 1.0. However, the constants, which in the first difference form yield coefficients on time, were retained with t values less than one. Since most fresh fruit consumption follows a downward trend due to decline in home canning and other factors, it was important to retain the time coefficients. A few substitutes with t values less than 1.0 were retained in the models on the basis of strong prior reasoning (Table 2). As an example, oranges were retained as a substitute for apples.

Estimates of the model specified in equation 1 along with three statistical properties (R^2, percent prior information, and the X^2 test for compatibility between sample and prior information) are shown in Table 2. For the two-stage and mixed two-stage least squares results, the R^2 is the square of the correlation between the actual value of the left-hand side variables and the predicted value. The predicted values were calculated using actual and not second stage values for right-hand variables. First stage predetermined variables included quantities of the fruit being analyzed, quantities of substitute fruits, and income in some cases.

Generally the mixed estimates of the coefficients on quantity were closer to the sample (as measured by the pure TSLS estimates) than to the prior information. The absolute value of the difference between the mixed and the sample estimates was less than .100 for 8 of the 14 fruits whereas only two fruits yielded differences between the prior and the mixed estimates of less than .100. The mean of the absolute difference between the sample and mixed coefficients was .154 in contrast to .231 for the mean of the absolute difference between the prior and the mixed estimates.

Generally the mixed estimates of the 37 cross price coefficients were closer to the prior estimates than to the pure sample estimates. The mean of the absolute value of the difference between the mixed and the prior sample estimates was .331 in contrast to .076 for the difference between the mixed and the prior. In five instances the direct application of two-stage least squares yielded negative signs on the price of other fruits indicating complementarity. In all five cases the mixed estimates had positive signs, implying a substitute relationship.

The percentage of the posterior precision attributable to the prior information ranged from a high of 61.4 percent for grapes to a low of 19.2 percent for prunes and plums. The average for the 14 fruits was 43.1 percent.

The compatibility test showed no conflict between sample and prior information at the .05 percent level for any of the 14 models. There were no large discrepancies between prior and sample coefficients on quantities, and sample information was not strong for coefficients on the price of substitutes. Thus, the lack of a significant conflict between the sample and prior information would be expected.

The income coefficient had t values above 1.0 only for sweet cherries, strawberries, and pears. Sweet cherries and strawberries are expensive relative to other fresh fruits. The coefficient for pears may reflect a taste factor which is increasing over time. Only the constant terms for fresh oranges and fresh strawberries had absolute t values greater than one. Both values were negative indicating that demand may be declining over time.

[5]Substitutes for strawberries and for sweet cherries were dropped in a second run because of low t values. These models were estimated by mixed OLS.

The R^2 values from the two-stage mixed estimations ranged from .84 for peaches to .31 for cantaloupes. For 10 of the 12 fruits estimated by TSLS the mixed estimate yielded higher R^2 values than did the non-mixed estimates. This is possible since the R^2 values were obtained by using actual values and not predicted values for the right-hand side endogenous variables. For the two fruits estimated with OLS, the R^2 values from the mixed procedure were slightly lower than from the non-mixed estimates, as would be expected.

The matrix of farm level demand elasticities for fresh fruits is shown in Table 3. The demands for apples, oranges and grapefruit were all inelastic. All three fruits are available during the winter months when competition from other fruits is minimal. The fruits sold only during the summer and early fall all have elastic demand schedules. Generally the minor fruits (in terms of quantities sold) have higher elasticities than major fruits. The outstanding exception is peaches for which there is no readily available explanation.

A comparison of these estimates with those of George and King shows similar direct price elasticities for apples and oranges. (Table 1). The cross elasticities between apples and oranges were both lower than the George and King estimates. However, the cross elasticities between apples and bananas were similar to the results of George and King.

The matrix of reduced form coefficients given in Table 4, is computed by[6]

$$\pi = B^{-1}\gamma$$

where B = the matrix of coefficients of the endogenous variables (Table 2), γ = the matrix of coefficients of the exogenous variables (Table 2), and π = the matrix of reduced of coefficients (Table 4).

The signs and magnitudes of the reduced form coefficients are consistent with theoretical and prior considerations. Coefficients of all quantities are negative, and coefficients on the quantities of substitutes are smaller than those of the direct price-quantity relationships.

Summary and Conclusions

The mixed estimation procedure increased the reliability of the measurements of cross elasticities for fresh fruits. It enabled more cross elasticities to be reliably measured than is possible with only the sample information. However, the number of cross elasticities that can be measured by this technique is limited. When many substitutes are included in an equation, the sample information's effectiveness is limited by multicollinearity and few degrees of freedom. The estimates are then dominated by the prior information and very little new information regarding the coefficients is gained.

The prior estimates were developed from a limited number of previous estimates by using the symmetry relationship, cross induction to fruits with similar characteristics, and subjective judgment. The success of this method is evidenced by the absence of significant conflict between the prior and the sample information. Thus, even though the symmetry relationship is not expected to hold at the farm level, for various reasons the lack of conflict between the sample and prior information gives some credence to the proposition that it may hold approximately at the farm level between commodities with similar types of marketing margins.

[6]This does not involve the usual problem of the reciprocal of the price flexibility being unequal to the price elasticity where important substitutes exist [Houck]. This problem would exist if equation (6) contained quantities of substitutes on the right-hand side instead of prices. The form estimated in this study (equation 6) does not yield what is usually termed price flexibilities.

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TABLE 2. Estimates of the Fresh Fruit Parameters

	PEACHES		
Regressor	Prior	TSLS	Mixed TSLS
Quantity Peaches	−.667	−.344 (4.30)	−.362 (4.89)
Price Grapes	.167	.149 (1.76)	.152 (2.08)
Price Cantaloupe	.250	.415 (1.46)	.344 (2.02)
Price Watermelon	.100	.127 (.87)	.123 (1.575)
Constant	---	−.0047 (.37)	−.0047 (.38)
R^2	---	.833	.840
% Prior Information	---	---	26.4
χ^2 Test of Compatibility	---	---	1.206
χ^2 .05	---	---	9.488

TABLE 2. (Continued)

		APPLES	
Regressor	Prior	TSLS	Mixed TSLS
Quantity Apples	−1.429	−1.801 (3.17)	−1.679 (4.05)
Price Pears	.128	.044 (.27)	.079 (.81)
Price Grapes	.071	.066 (.37)	.061 (.94)
Price Bananas	.171	−.845 (.62)	.168 (1.00)
Price Oranges	.257	−.247 (.61)	.085 (.56)
Constant	---	−.0040 (.12)	−.0031 (.25
R^2	---	.340	.549
% Prior Information	---	---	51.0
χ^2 Test of Compatibility	---	---	1.861
χ^2 .05	---	---	11.070

		ORANGES	
Regressor	Prior	TSLS	Mixed TSLS
Quantity Oranges	−2.000	−2.123 (1.08)	−1.516 (3.48)
Price Grapes	.100	.431 (.93)	.136 (1.46)
Price Bananas	.100	1.061 (.35)	.102 (1.02)
Price Tangerines	.120	.033 (.06)	.141 (1.26)
Constant	---	−.089 (.94)	−.052 (1.20)
R^2	---	.371	.599
% Prior Information	---	---	57.4
χ^2 Test of Compatibility	---	---	1.181
χ^2 .05	---	---	9.488

TABLE 2. (Continued)

PLUMS

Regressor	Prior	TSLS	Mixed TSLS
Quantity Plums	−.556	−.969 (7.91)	−.897 (8.09)
Price Peaches	.333	.409 (.95)	.556 (2.54)
Price Prunes & Plums	.178	.251 (1.56)	.215 (2.36)
Price Cantaloupe	.256	1.284 (.38)	.379 (1.59)
Price Watermelon	.083	.047 (.13)	.094 (1.18)
Constant	---	−.009 (.26)	−.002 (.01)
R^2	---	.781	.806
% Prior Information	---	---	44.0
χ^2 Test of Compatibility	---	---	3.950
χ^2 .05	---	---	11.070

GRAPES

Regressor	Prior	TSLS	Mixed TSLS
Quantity Grapes	−.667	−1.274 (3.08)	−.856 (3.67)
Price Peaches	.331	1.181 (2.40)	.606 (2.54)
Price Plums	.060	.203 (1.32)	.073 (1.32)
Price Cantaloupe	.253	−1.833 (1.74)	.194 (.82)
Price Watermelon	.067	.464 (1.054)	.068 (1.04)
Constant	---	−.0073 (.18)	.0077 (.19)
R^2	---	.625	.514
% Prior Information	---	---	61.4
χ^2 Test of Compatibility	---	---	5.723
χ^2 .05	---	---	11.070

TABLE 2. (Continued)

PEARS

Regressor	Prior	TSLS	Mixed TSLS
Quantity Pears	−.667	−.976 (3.91)	−.906 (5.67)
Price Apples	.467	.131 (.18)	.413 (1.62)
Price Grapes	.052	.025 (.114)	.054 (1.07)
Price Bananas	.133	−1.224 (.175)	.144 (1.10)
Income	.090	5.245 (.27)	.092 (1.02)
Constant	---	−.126 (.29)	−.013 (.32)
R^2	---	.584	.811
% Prior Information	---	---	57.2
χ^2 Test of Compatibility	---	---	1.141
χ^2 .05	---	---	11.070

WATERMELON

Regressor	Prior	TSLS	Mixed TSLS
Quantity Watermelon	−.667	−1.224 (3.38)	−.902 (3.79)
Price Peaches	.173	−.250 (.80)	.153 (1.08)
Price Cantaloupe	.396	1.478 (2.61)	.719 (2.42)
Constant	---	−.015 (.60)	−.011 (.45)
R^2	---	.645	.591
% Prior Information	---	---	43.6
χ^2 Test of Compatibility	---	---	3.690
χ^2 .05	---	---	7.815

TABLE 2. (Continued)

NECTARINES

Regressor	Prior	TSLS	Mixed TSLS
Quantity Nectarines	−.500	−.650 (2.87)	−.521 (3.80)
Price Peaches	.400	.340 (.77)	.537 (2.23)
Price Cantaloupe	.200	.905 (.78)	.241 (1.24)
Price Watermelon	.100	.200 (.47)	.120 (1.26)
Constant	---	.032 (.88)	.029 (.82)
R^2	---	.366	.502
% Prior Information	---	---	50.2
χ^2 Test of Compatibility	---	---	.917
χ^2 .05	---	---	9.488

GRAPEFRUIT

Regressor	Prior	TSLS	Mixed TSLS
Quantity Grapefruit	−2.000	−1.574 (3.10)	−1.481 (4.64)
Price Bananas	.100	.377 (.33)	.106 (1.07)
Price Oranges	.500	.038 (.14)	.080 (.37)
Constant	---	−.0013 (.04)	−.0001 (.002)
R^2	---	.497	.542
% Prior Information	---	---	31.9
χ^2 Test of Compatibility	---	---	1.158
χ^2 .05	---	---	7.815

TABLE 2. (Continued)

SWEET CHERRIES

Regressor	Prior	TSLS	Mixed TSLS
Quantity Sweet Cherries	−.417	−.566 (8.18)	−.558 (8.51)
Income	.250	2.307 (1.87)	.332 (1.35)
Constant	---	−.051 (1.30)	−.0015 (.06)
R^2	---	.752	.726
% Prior Information	---	---	35.3
χ^2 Test of Compatibility	---	---	3.168
χ^2 .05	---	---	5.991

STRAWBERRIES

Regressor	Prior	TSLS	Mixed TSLS
Quantity Strawberries	−.417	−.527 (1.98)	−.511 (5.97)
Income	.167	.921 (1.83)	.246 (1.51)
Constant	---	−.032 (1.98)	−.015 (1.40)
R^2	---	.596	.566
% Prior Information	---	---	35.5
χ^2 Test of Compatibility	---	---	2.252
χ^2 .05	---	---	5.991

TABLE 2. (Continued)

	TANGERINES		
Regressor	Prior	TSLS	Mixed TSLS
Quantity Tangerines	−.667	−.490 (2.59)	−.478 (3.12)
Price Apples	.213	.068 (.24)	.163 (1.00)
Price Grapes	.047	.359 (1.57)	.065 (1.43)
Price Bananas	.136	.246 (.22)	.148 (1.11)
Price Oranges	.467	.140 (.43)	.326 (1.55)
Price Grapefruit	.053	.243 (.90)	.062 (1.21)
Constant	---	−.017 (.45)	−.0024 (.07)
R^2	---	.472	.653
% Prior Information	---	---	55.3
χ^2 Test of Compatibility	---	---	3.906
χ^2 .05	---	---	12.592

	PRUNES & PLUMS		
Regressor	Prior	TSLS	Mixed TSLS
Quantity Prune & Plums	−.556	−.755 (6.44)	−.755 (7.86)
Price Grapes	.167	.299 (1.47)	.235 (1.85)
Price Plums	.444	.265 (2.22)	.284 (2.47)
Constant	---	−.032 (.98)	−.029 (.90)
R^2	---	.824	.823
% Prior Information	---	---	19.2
χ^2 Test of Compatibility	---	---	.982
χ^2 .05	---	---	7.815

TABLE 2. (Continued)

	CANTALOUPE		
Regressor	Prior	TSLS	Mixed TSLS
Quantity Cantaloupe	−.667	−.832 (2.11)	−.696 (3.00)
Price Grapes	.167	.266 (1.02)	.158 (1.31)
Price Peaches	.333	.008 (.19)	.202 (1.00)
Constant	---	−.015 (.61)	−.011 (.50)
R^2	---	.202	.311
% Prior Information	---	---	34.5
χ^2 Test of Compatibility	---	---	.393
χ^2 .05	---	---	7.815

TABLE 3. Demand Elasticities for Fresh Fruits Estimated by Mixed Estimation

	Apples	Pears	Oranges	Tange-rines	Grape-fruit	Peaches	Canta-loupe	Water-melon	Plums	Prunes & Plums	Grapes	Nectar-ines	Sweet Cherries	Straw-berries	Bananas	Income
Apples	−.596	.047	.051													
Pears	.456	−1.104									.036				.100	
Oranges			−.660	.093							.060				.159	.102
Tangerines	.341		.682	−2.092	.130						.090				.067	
Grapefruit			.054		−.675						.136				.310	
Peaches						−2.762	.950	.340							.072	
Cantaloupe						.290	−1.437				.420					
Watermelon						.170	.797	−1.109			.227					
Plums						.620	.422	.105	−1.115	.240						
Prunes & Plums									.376	−1.324	.311					
Grapes						.708	.229	.079	.085		−1.168					
Nectarines						1.031	.462	.230				−1.919				
Sweet Cherries													−1.792			.595
Strawberries														−1.957		.441

TABLE 4. Reduced Form of the Demand Coefficients for Fresh Fruits (Price Flexibility Matrix)

Dependent Variable: Price	Constant (Time)	Quantity Apples	Quantity Pears	Quantity Oranges	Quantity Tange-rines	Quantity Grape-fruit	Quantity Peaches	Quantity Nectar-ines	Quantity Plums	Quantity Prunes & Plums	Quantity Canta-loupe	Quantity Water-melon	Quantity Grapes	Quantity Bananas	Quantity Sweet Cherries	Quantity Straw-berries	Income
Apples	−.0179	−1.7920	−.0704	−.1443	−.0064	−.0012	−.0366	0	−.0088	−.0016	−.0547	−.0198	−.1078	−.0902	0	0	.0953
Pears	−.0230	−.7785	−.9392	−.0627	−.0028	−.0005	−.0399	0	−.0096	−.0017	−.0597	−.0216	−.1176	−.1031	0	0	.1955
Oranges	−.0584	−.0779	−.0033	−1.596	−.0710	−.0136	−.0620	0	−.0149	−.0027	−.0928	−.0335	−.1828	−.0616	0	0	.0601
Tangerines	−.0275	−.3591	−.0153	−.5552	−.5027	−.0966	−.0557	0	−.0134	−.0024	−.0834	−.0301	−.1642	−.1058	0	0	.0142
Grapefruit	−.0064	−.0345	−.0015	−.1300	−.0058	−1.482	−.0083	0	−.0020	−.0004	−.0124	−.0045	−.0245	−.0534	0	0	.0520
Peaches	−.0138	0	0	0	0	0	−.4973	0	−.0222	−.0040	−.4749	−.1740	−.2721	0	0	0	0
Nectarines	.151	0	0	0	0	0	−.3284	−.5210	−.0184	−.0033	−.5519	−.2268	−.2262	0	0	0	0
Plums	−.0258	0	0	0	0	0	−.3981	0	−.9825	−.1778	−.7374	−.2388	−.3338	0	0	0	0
Prunes & Plums	−.0380	0	0	0	0	0	−.2010	0 0	−.3002	−.8093	−.3411	−.1154	−.3542	0	0	0	0
Cantaloupe	−.0149	0	0	0	0	0	−.1596	0	−.0187	−.0034	−.8805	−.0671	−.2294	0	0	0	0
Watermelon	−.0238	0	0	0	0	0	−.1908	0	−.0168	−.0030	−.7057	−.4769	−.2065	0	0	0	0
Grapes	−.0071	0	0	0	0	0	−.3744	0	−.0899	−.0163	−.5604	−.2023	−1.104	0	0	0	0
Sweet Cherries	−.0015	0	0	0	0	0	0	0	0	0	0	0	0	0	−.5576	0	.3316
Strawberries	−.0150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	−.5111	.2464