Estimates of Demand Relationships for Apricots and Apricot Products

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Apricots are a unique commodity in that they are used in four ways: for fresh markets and for canning, freezing, and drying. This article formulates a model of the demand system for this commodity and presents FIML and 2SLS estimates of the simultaneous components of the system. The empirical findings include estimates of price flexibilities and elasticities and equations that predict prices and allocations among product forms, given the annual production.

Key words: apricots, derived demand, econometric model, processed fruit, pure flexibilities.

Apricots are canned, frozen, dried, and marketed fresh. The prices received by processors and growers are determined by an interrelated structure of derived demands, grower allocation decisions, and processor-grower bargaining. This article formulates a conceptual model of the structure of this system and presents estimates of price elasticities (or price flexibilities) for the four product forms at processor and farm levels. While the empirical findings are specific to apricots, the modeling approach is applicable to other processed fruit and vegetables.

Background Information

Over 95% of U.S. apricot production is in California. The balance is grown in Washington and Utah (primarily Washington) with most of the Washington-Utah crop sold for fresh use. Table 1 shows the quantities of apricots produced in California over the period 1956 to 1989 (years grouped to save space) and the allocation of the output among the four utilization forms. Table 2 shows the quantities produced in Washington and Utah and the quantities of canned and dried apricots exported and imported nationally. Some fresh market apricots also are exported but the amounts have not been reported separately since 1976.

Beginning in the 1970s, California apricot output (and acreage) declined substantially, falling to about half of the pre-1970 level by 1986–89. The decrease appears to have been primarily in response to reduced grower returns associated with declining demand, especially in the major canned product market. Some of the reduction in canning was offset by increases in freezing, but the combined canning-freezing tonnage in 1986–89 was still less than half of the pre-1970 level. Canned exports also declined substantially while canned imports, nearly nonexistent before 1980, became significant in the 1980s.

California fresh market production and sales declined in the 1960s and 1970s, but increased again in the 1980s. Washington-Utah fresh production followed a similar pattern (table 2). Most California shipments are in May and June whereas Washington-Utah shipments are in July and August, so there is little interregional competition.

Dried apricot production declined absolutely in the 1980s but with some increase in utilization share compared to pre-1975 levels. At the same time, imports of dried apricots (mainly from Turkey) increased sharply, substantially exceeding U.S. production in the 1980s.

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Table 1. Production and Utilization of California Apricots, 1956-89 (Average Annual Values, Fresh Weight)

	Production	Utilization							
		Fresh Market		Canned		Frozen		Dried	
Period	1,000 tons	1,000 tons	%	1,000 tons	%	1,000 tons	%	1,000 tons	%
1956–60	175.7	11.6	6.6	119.2	67.8	3.5	2.0	41.4	23.6
1961–65	185.0	12.9	7.0	129.5	70.0	7.1	3.8	35.5	19.2
1966–70	173.0	9.6	5.5	122.6	70.9	8.3	4.8	32.5	18.8
1971–75	137.0	8.3	6.1	98.5	71.9	8.4	6.1	21.8	15.9
1976–80	129.8	7.9	6.1	79.5	61.2	9.4	7.2	33.0	25.5
1981–85	101.3	10.6	10.4	55.4	54.7	11.0	10.9	24.3	24.0
1986–89	87.5	11.2	12.8	47.4	54.2	11.0	12.6	17.9	20.4

Source: Annual reports of the U.S. Agricultural Statistics Board.

Table 3 shows the overall movement of the average annual deflated prices for apricots and apricot products from 1956 to 1988. The reported grower fresh market price is based on graded fruit and does not allow for the substantial quantities culled. Hence, it is higher than the grower price for fresh apricots used for canning and freezing. Other things accounting for the fresh-canning price differences are quality factors, time of harvest, and possibly some lags in adjusting allocations to changes in market returns. The grower price for fresh apricots allocated to drying is the price after drying, expressed per equivalent raw-product ton. The higher value reflects the added cost of drying and quality and varietal differences.[1]

The APC, a farmer cooperative, plays an important role in determining prices received by growers for apricots used for processing. Organized in 1961 to provide information and services to growers, its major function since 1974 has been to bargain with private (nonco-op) processors over prices and terms of trade for its members. The negotiated prices tend to set the industry standard. Data from APC indicate that in 1990 there were nine apricot canning firms (two cooperatives and some firms with more than one plant), six freezers, and 22 dryers. Since 1971 the industry has supported a state marketing order program to improve demand through advertising, promotion, and product research.

Structure of Demand

Because Washington-Utah apricot production was primarily for fresh market sales during the years included in this study and was mostly sold in different months than California fresh apricots, the analysis that follows focuses only on the California industry. A demand model for Washington apricots was estimated by Price for an earlier period (1948–64 data).

The California demand model is conceived to include the following types of relationships:

(*a*) derived demand functions facing processors of canned, dried, and frozen apricots;
(*b*) derived demand functions for imported canned and dried apricots (if U.S. and imported apricots are differentiated in the minds of buyers);[2]
(*c*) import supply functions for canned and dried apricots;
(*d*) functions which allocate available U.S. processed product supply between current sales and carry-over to the next year;
(*e*) derived demand functions facing California fresh-market apricot growers;

[1] In the 1950s and 1960s many growers dried their own apricots. The grower prices reported by the California Crop Reporting Service (CRS), although expressed in fresh equivalents, reflected the added cost of drying. With the growth of commercial dry yards and price bargaining by the Apricot Producers of California (APC), the CRS in 1977 shifted to direct reporting of prices received by growers for fresh apricots sold to dryers. However, this shift was not noted in the CRS reports. To maintain the consistency of the price series over time, prices in table 3 are prices paid to dryers by packers, as reported in the annual Federal-State Market News reports, *Marketing California Dried Fruits*, expressed in equivalent fresh weight. Since 1977, grower prices for fresh apricots used for drying have averaged about 20% higher than prices for fresh fruit used for canning, reflecting differences in product characteristics.

[2] Frozen apricots are not imported or exported in significant quantities.

Table 2. Washington-Utah Apricot Production and U.S. Exports and Imports of Canned and Dried Apricots, 1956–88 (Average Annual Values)

Period	Washington-Utah		U.S. Canned Apricots			U.S. Dried Apricots		
	Total[a]	Fresh	Exports (a)	Imports (b)	(a) − (b)	Exports (c)	Imports (d)	(c) − (d)
	1,000 tons		1,000 tons fresh equiv.			1,000 tons fresh equiv.		
1956–60	14.4	9.6	7.2	0	7.2	8.3	0	8.3
1961–65	8.8	6.7	6.2	0	6.2	7.1	1.9	5.2
1966–70	5.9	4.7	2.1	0	2.1	4.8	6.1	−1.3
1971–75	3.8	3.4	2.5	0	2.5	4.7	9.0	−4.3
1976–80	4.2	3.8	2.1	.4	1.7	4.6	15.8	−11.2
1981–85	3.4	3.1	1.1	8.2	−7.1	3.6	32.0	−28.4
1986–88	5.7	5.4	1.0	11.2	−10.2	2.8	46.1	−43.3

Source: Compiled from annual reports of the Federal-State Market News Service (*Marketing California Apricots* and *Marketing California Dried Fruit*) and the U.S. Agricultural Statistics Board.
[a] Utilized production.

(*f*) grower-level pricing equations for apricots utilized for processing which reflect outcomes of grower-processor bargaining; and
(*g*) restrictions and conditions which influence the allocation of total apricot production among utilization forms.

The equations in the first four types of relationships form a jointly related system which will be called the Processed Product Block; the remaining relationships form another simultaneous system which will be called the Raw Product Block. The model is block recursive in that the endogenous quantities allocated to each processing use, determined in the Raw Product Block, enter (with appropriate conversion ratios) as predetermined pack variables in the Processed Product Block. The conceptual model is set out below in greater detail.

Processed Product Block

The demand functions facing processors of canned, frozen, and dried apricots are derived from U.S. consumer and food manufacturer demands and from foreign demands. The functions are conceptualized with the f.o.b. processor price expressed as a function of U.S. shipments and imports (relative to U.S. population) and exogenous demand shifters such as per capita income, competing products, and other variables to account for difficult to mea-

Table 3. Average Annual Prices Received by Growers and Processors of Apricots, 1956–88, in 1967 Dollars

Period	Grower Price, Dollars per Raw Ton				F.o.b. Processor Price		
	Fresh	Canning	Freezing	Drying[a]	Canned[b]	Frozen[c]	Dried[d]
1956–60	171	125	131	201	6.78	16.7	71.5
1961–65	136	99	103	182	5.69	15.6	72.0
1966–70	200	108	107	187	5.79	17.7	74.8
1971–75	236	94	98	193	6.86	17.8	82.1
1976–80	221	97	91	191	7.18	20.2	99.5
1981–85	197	93	94	237	7.85	20.9[e]	111.9
1986–88	257	85	92	210	7.55	NA	108.3

Source: Computed from reports of the Federal-State Market News Service (*Marketing California Apricots* and *Marketing California Dried Fruit*); Kuznets; Judge; American Institute of Food Distribution; and *Pacific Fruit News*.
Note: Prices were deflated by the Personal Consumption Expenditure Deflator. PCE = 100 in 1967, 316 in 1988.
[a] Price received at dry yards for No. 1 grade in raw-product equivalents; reflects drying cost.
[b] Dollars per case of 24 No. 2½ cans, choice.
[c] Cents per pound in 30-pound containers, grade B or better.
[d] Price received by packers for the dried product, cents per pound, extra-choice Blenheim.
[e] 1981–84 average.

sure changes in consumer preferences and shifts in foreign demand.

Separate demand functions for imports are required only if the imported products are strongly differentiated in the minds of buyers. Lacking consistent time-series data on import prices, we make the reasonable assumptions that imports are close substitutes for U.S. products and that prices paid for imports and U.S. prices are highly correlated. With a unit of imports assumed to have the same effect on U.S. f.o.b. processor prices as a unit of U.S. product, separate import demand functions are not specified.

The quantities of canned and dried imports supplied to the U.S. market are determined by the price paid for imports (replaced by the U.S. f.o.b. price under the previously explained assumption) and a complex set of international production and trade variables.

Apricots are harvested and processed within a relatively short period, primarily in June and July. The marketing year for canned, dried, and frozen apricots runs from 1 June to 31 May. Quantities of processed apricots available for sale consist of the current pack, plus stocks carried over from the previous year, plus imports. Because processors have the option of carrying some of the seasonal supply to the next year, the marketing-year processed product prices, movements, and carry-over stocks are jointly determined.

The model to predict the quantities allocated to current-year sales, given the available supply, is adapted from a study of the demand for canned peaches by French and King (FK). Processors are initially and primarily concerned with marketing their supplies (pack plus carry-in) so as to achieve prices that will cover the previously incurred processing and raw products costs, make a positive return on investment, and result in an adequate but not burdensome carry-out at the end of the marketing season. Processors also take account of variations in current market conditions as reflected by observed current (marketing-year) movement relative to the total supply. Hence, the allocation relationships involve current movement and f.o.b. processor price as endogenous variables and total supply, unit processing and raw product costs, and population (market size) as primary shifters.

In a simultaneous system the choice of a normalized variable for each equation depends on how one views the causal structure. With relatively few peach canners and probably a dominant price leader, FK's model emphasized price setting. The current market allocation was determined by a "price-markup function" which expressed the f.o.b. processor price as a function of unit processing and raw product costs and the ratio of movement to the predetermined supply. With the assumption of price-setting behavior, demand was normalized on quantity. The model for apricots normalizes the demand functions on price rather than quantity, with the allocation relationships normalized on movement. While either normalization yields significant estimates of the canned product equation system, the price-dependent formulation yields more consistent results for dried apricots which include a large import component.

With the above considerations, the processed product block consists of the following structural relationships (normalized variable left of colon; exogenous and predetermined variables right of semicolon; variable identification in table 4):

F.o.b. demand facing processors:

(1) *PPC*: *DCN, DDN, DFN*; *ZC* (canned product),
(2) *PPD*: *DCN, DDN, DFN*; *ZD* (dried product), and
(3) *PPF*: *DCN, DDN, DFN*; *ZF* (frozen product).

Market allocation:

(4) *DCN*: *PPC, ICN*; *TSCN, CPC, PGC* (canned product),
(5) *DDN*: *PPD, IDN*; *TSDN, CPD, PGD* (dried product), and
(6) *DFN*: *PPF*; *TSFN, CPF, PGF* (frozen product).

Import supply:

(7) *ICN*: *PPC*; *AC* (canned imports), and
(8) *IDN*: *PPD*; *AD* (dried imports).

Stocks carried over (*SC, SD, SF*) are determined by the identities $SC_{t+1} = TSC + IC - DC$; $SD_{t+1} = TSD + ID - DD$; $SF_{t+1} = TSF - DF$ where exclusion of *N* indicates total rather than per capita values.

Raw Product Block

In the fresh apricot market, growers are faced by a competitive demand function derived from consumer and market intermediary demands. In the processing market, however, the

Table 4. Variable Identification for the Conceptual Model

Variable[a]	Definition
PPC, PPD, PPF	Marketing-year average f.o.b. processor price (deflated)
DCN, DDN, DFN	U.S. marketing-year shipments plus imports, expressed relative to U.S. population (*N*)
ZC, ZD, ZF, ZR	Vectors of demand shifters
TSCN, TSDN, TSFN	Total U.S. supply (pack plus carry-in) relative to U.S. population
CPC, CPD, CPF	Unit processing cost (deflated)
PGC, PGD, PGF, PGR	Raw product prices (deflated)[b]
ICN, IDN	Imports relative to U.S. population
AC, AD	Import supply shifters
QGCN, QGDN, QGFN, QGRN	Raw product quantity relative to U.S. population
WC, WD, WF	Vectors of variables that reflect both grower and processor expectations of demand and profitability of processed products
QG	Total annual California apricot production
QGC, QGD, QGF, QGR	Raw product utilized in form *C, D, F,* or *R*
MDR, MDD, MDF	Constant which converts systematic differences in reported average prices to equivalent at-farm returns (compared to the price for canning apricots)
ER, ED, EF	Random deviations from *MDR, MDD, MDF*

[a] Last letter (before *N* for quantities) indicates canned (*C*), dried (*D*), frozen (*F*), or fresh (*R*) product or use. Canned and frozen combined is designated by *CF,* for example *QGCFN.* An *N* appended indicates a U.S. per capita value (×1,000).
[b] Price for dried apricots is price per equivalent raw-product ton after drying. See text footnote 1.

presence of a grower-processor bargaining structure, at least since 1974, suggests that grower-level demand functions for apricots used for canning, drying, and freezing may not be uniquely defined, as they would be under perfect competition.[3] The farm price may be established within a range of bargaining space, with the size of the space and the location of the price within the space influenced by factors such as price elasticities of processed product demand, nonmember supply, bargaining tactics, alternative markets, and the financial strength of processors. French showed that even if a farm-level demand function is not defined, consistent price predictions of the raw product price (*PG*) may be obtained as a function of the quantity of raw product purchased (*QGN*) and other variables (*W*) that reflect grower and processor expectations of processed product demand and profitability and, hence, influence the outcomes of the bargaining process. With these considerations, the structural components of grower price determination consist of the following (variables defined in table 4):

(9) PGR: $QGRN$; ZR (grower price, fresh use),
(10) PGC: $QGCN$; WC (grower price, canning use),
(11) PGD: $QGDN$; WD (grower price, drying use), and
(12) PGF: $QGFN$; WF (grower price, freezing use).

[3] The theoretical foundations of grower-processor bargaining for fruits and vegetables are developed in the seminal work of Helmberger and Hoos.

Reported raw product prices for apricots used in each form differ both systematically and randomly due to variations in size, quality and variety characteristics, differences in the way prices are reported, possible differences due to location and harvest time, and deviations due to incomplete information and rigidities within the system. With adjustments for the systematic (mean) differences (*MD*), we would expect prices to be equal in each outlet except for random deviations (*E*). Hence, the allocations among utilization forms are constrained as follows:

(13) $PGR - PGC = MDR + ER$ (fresh-canning price difference),
(14) $PGD - PGC = MDD + ED$ (dried-canning price difference),
(15) $PGF - PGC = MDF + EF$ (freezing-canning price difference), and
(16) $QG = QGC + QGF + QGD + QGR$ (allocation identity),

where *C, D, F,* and *R* are as defined in table 4. Equations (9) to (16) form an eight-equation simultaneous system.

Data

The f.o.b. processor prices are representative values obtained from trade journal reports. The price of canned apricots (*PPC*) is represented by the price per case of 24 No. 2½ cans, choice grade. The f.o.b. packer price for dried apricots

(*PPD*) is expressed as cents per pound of extra-choice Blenheim apricots. The frozen price is in cents per pound for bulk apricots, grade B or better. The grower prices are per ton of equivalent raw product.

The canned pack and stocks are measured in equivalent cases of 24 No. 2½ cans. Frozen and dried apricots are measured in pounds. Raw product quantities are in tons. All prices and cost data are deflated by the Personal Consumption Expenditure deflator, 1967 = 1. Quantity variables are expressed per 1,000 U.S. population.

Import quantities are available only for calendar years. The calendar year values are assigned to the corresponding crop year. For example, imports for calendar year 1960 are assigned to crop year 1960/61. This results in a slight distortion of the marketing-year dried apricot consumption values (*DDN*).[4]

The data set used for estimation covers the period 1956–88. The model was initially estimated with data for 1956–86 (one observation lost in the Processed Product Block and two observations lost in the Raw Product Block due to lagged variables). Out-of-sample predictions for 1987 and 1988 were all within three root-mean-square errors of the regression equations and most (all but two) were within two or less.[5] Since there was no clear evidence of structural shifts in the out-of-sample predictions, the model was re-estimated with 1956–88 data in order to use all available information.

Empirical Specifications

Before undertaking empirical estimation, the conceptual model requires some modification to accommodate data limitations and further elaboration to identify the variables *ZC, ZF, ZD,* and *ZR* which account for shifts in the levels of product demand over the observation period, variables *AC* and *AD* which account for shifts in the import supply functions, and variables *WC, WD,* and *WF* which influence the outcomes of grower-processor bargaining with respect to raw product prices.

Modifications Due to Data Limitations

F.o.b. processor price data for frozen apricots are available only to 1984 and the consistency over time of both the frozen product price and quantity data appears to be questionable. Further, in initial empirical explorations using data up to 1984, it was found that frozen per capita quantity (*DFN*) was not a significant variable in the canned product demand equation [equation (1)] and the estimate of the f.o.b. frozen product demand function [equation (3)] had very low explanatory power. It appears that the price-quantity relationships reflected by the uncertain and incomplete data in the frozen product market are dominated by the much larger and more predictable canned market.

Because of these problems, the separate frozen product demand equation (3) was eliminated from the model and the frozen and canned quantities were aggregated into a single canned-frozen component, *DCFN*. The canned product is converted from cases of 24 No. 2½ cans at 31.25 pounds per case, and frozen apricots are expressed as .91 equivalent pounds per pound of packaged frozen apricots (see Judge 1990, pp. 633, 634). Hence, $DCFN = 31.25DCN + .91DFN$. Frozen apricots, which are mainly packed in bulk form for institutional use, are substitutes for or may compete with the institutional-size pack of canned apricots. The latter accounted for about 45% of the canned pack (in equivalent units) for the period 1980–89. The f.o.b. price for canned apricots serves as the representative price for this group. During the period of available data, the correlation between the reported deflated f.o.b. processor prices for canned and frozen apricots was $r = .79$.[6]

Prices received by growers for apricots utilized for canning and freezing are nearly iden-

[4] Reported carry-over stocks of dried apricots (*SD*) include some unknown quantity of imports. Hence, computation of movement of U.S.-produced dried apricots is subject to possible error. Total consumption (*DD*) is accurately computed by $DD = QD + SD + ID - SD_{t+1}$ (where *QD* is quantity packed), subject to discrepancies because *ID* refers to calendar year imports whereas *SD* is measured at the beginning of the crop year.

[5] The prediction deviations might more appropriately be examined in relation to confidence intervals based on standard forecast errors. However, the standard forecast error will, in general, not be less than the standard error of the regression. Since the prediction errors fell within the narrower range, standard forecast errors, which involve complex calculations in a simultaneous equation system, were not computed.

[6] An alternative procedure would be to eliminate the frozen component entirely—treating it as exogenous. Because the quantity of frozen apricots is small relative to the canned quantity, the overall statistical results under this specification were not greatly altered.

tical. The two quantities are expressed as a single variable, $QGCFN = QGCN + QGFN$. Conceptual equations (10) and (12) are combined (with *PGC* retained as the representative price) and restriction equation (15) is eliminated.

Because the growth in imports of canned apricots has been recent (table 2), there are insufficient observations to estimate an import supply function for this component. Therefore, *ICN* is treated as an exogenous variable and conceptual equation (7) is eliminated.

Processed Product Block Specifications

The most difficult aspect of estimating demand functions for processed apricot products is to account for and measure shifts in the level of demand over the observation period (the unspecified variables *ZC, ZF,* and *ZD* in the conceptual model). The effects of commonly used variables such as per capita income and supplies or prices of competing products tend to be obscured by more fundamental changes in consumption habits.

An unpublished study of apricot product demand by Eryilmaz for the period 1953–74 found that there was (*a*) a downward trend in the per capita demand function for canned apricots, (*b*) an upward trend in the demand function for frozen apricots (accounting for some of the decline in demand for canned apricots), (*c*) little change in the level of per capita demand for dried apricots, and (*d*) a downward movement in per capita fresh market demand. The demand shifts were not significantly related to changes in income. It is possible that some of the shifts noted by Eryilmaz, and beyond, were due to relative price changes for other fruits but such substitution relationships as may have existed were obscured by shifts in general levels of demand for all canned, frozen, dried, and fresh fruit—especially increased preferences for fresh and decreased preferences for traditional canned fruit in the late 1970s and 1980s. Variables which might account for shifts in the relatively small export markets, other than these trends, were not measured.

To account for the possible effects of changes in the unmeasurable or difficult to measure demand shift variables, we introduced a piecewise linear-quadratic trend variable of the form $\alpha_1 T + \alpha_2 TC + \alpha_3 (TC)^2$, where T = year (57, 58, . . . , 88), $TC = D(T-73)$, and D is zero prior to 1973, one in 1973 and after.[7] This permits the trends indicated in the Eryilmaz study to change at about the time of the Arab Oil Embargo and double-digit inflation in 1973/74 and at roughly the start of the marketing order program for advertising and promotion and the beginning of increasing levels of demand for dried apricots. An increase in dried apricot demand is suggested by the simultaneous increases in total U.S. per capita consumption and deflated prices (see tables 1–3). The quadratic form of *TC* allows the trend slope to change as time moves forward. Alternative models with the dummy shifter *D* set at one in 1972 and 1974 (thus changing the starting value of *TC*) yielded estimates with larger variances.

With these considerations, the demand functions facing processors are expressed as the following linear approximations:

$$\text{(1a)} \quad PPC = b_{10} + b_{11}DCFN + b_{12}DDN + b_{13}T + b_{14}TC + b_{15}(TC)^2 + u_1, \quad \text{and}$$

$$\text{(2a)} \quad PPD = b_{20} + b_{21}DCFN + b_{22}DDN + b_{23}T + b_{24}TC + b_{15}(TC)^2 + u_2,$$

where (1a) combines and replaces (1) and (3) in the structural model, $DCFN = 31.25DCN + .91DFN$, and the other variables are as defined above and in table 4. The effects of varying the trend specifications are investigated in the empirical estimation.[8]

A desirable property of the market allocation equations is that in long-run equilibrium (constant prices and costs), the predicted movement relative to the total supply should approximate the observed multiyear average of this ratio. For example, on average, about 75% of the canned and frozen apricot supply in year t has been marketed in t, with the balance carried to $t + 1$. One means of imposing such a relationship is to express the price and cost variables as year-to-year differences. The allocation equations then are as follows [replacing conceptual equations (4), (5), and (6)]:

$$\text{(3a)} \quad DCFN = b_{30} + b_{31}TSCFIN + b_{32}\Delta PPC + b_{33}\Delta PGC + b_{34}\Delta IPCE + u_3,$$

[7] The computation of *TC* gives $TC = 0$ prior to and including 1973, $TC = 1$ in 1974, 2 in 1975, and so on.

[8] It is possible that the slope coefficients b_{11} and b_{22} may have changed over the period of study as well as the levels of demand, but that is difficult to test with limited observations. Nonlinear equation forms were also explored, but estimates based on the linear model provided generally better fits to the data than alternative log or semilog formulations.

(4a) $DDN = b_{40} + b_{41}TSDIN + b_{42}\Delta PPD + b_{43}\Delta PGD + b_{44}\Delta IPCE + u_4,$

(5a) $TSDIN = TSDN + IDN,$

(6a) $\Delta PPC = PPC - PPCL,$ and

(7a) $\Delta PPD = PPD - PPDL,$

where an *L* suffix indicates a one-year lag. The variables not previously defined in table 4 are identified in table 5. *IPCE* replaces unknown values of unit processing costs, *CPC, CPF,* and *CPD* in conceptual equations (4), (5), and (6). The changes in processing and raw product cost indicators ($\Delta IPCE$, ΔPGC, and ΔPGD) are predetermined, whereas ΔPPC and ΔPPD are endogenous within this block.

In the dried import supply equation (8), *AD* is replaced by total apricot production in Turkey and Australia (the main exporters to the United States), expressed relative to U.S. population (*TAPN*). To account for lags in import supply response, *PPD* is replaced by *PPD*2 where $PPD2 = .5(PPD + PPDL)$. The supply equation then becomes

(8a) $IDN = b_{50} + b_{51}PPD2 + b_{52}TAPN + u_5.$

Equations (1a) to (8a) form an eight-equation simultaneous model of the processed product block. Endogenous variables are: *PPC, PPD, DCFN, TSDIN, DDN, IDN,* ΔPPC, and ΔPPD. Exogenous and predetermined variables are *T, TC,* $(TC)^2$, *TSCFIN, TSDN,* $\Delta IPCE$, *PPCL, PPDL,* ΔPGC, ΔPGD, and *ICN.*

Raw Product Block Specifications

To allow for such shifts as may have occurred in the level of fresh market demand, we included the same time-form shifters as in the processed product demands.[9] Thus structural equation (9) becomes

(9a) $PGR = b_{60} + b_{61}QGRN + b_{62}T + b_{63}TC + b_{64}(TC)^2 + b_{65}D + u_6,$

where the variable *D,* which is zero prior to 1973 and one thereafter, is introduced to account for a possible change in price reporting beginning in the mid-1970s.[10] The other variables are as defined in table 4 or table 5.

Variables thought to affect the price outcomes of grower-processor bargaining include, in addition to the quantity purchased for processing, stocks carried over from the previous year (*SCFRN, SDRN*), lagged processed product per capita movement (*DCFNU2L, DDNU2L*), lagged processed product prices (*PPCL, PPDL*), and an indicator of processing cost, *IPCEL* (replacing variables *WC, WF,* and *WD* in the structural set). An increase in average per capita movement with the f.o.b. price constant or an increase in price with average movement constant signals increases in the level of demand. The previous-period price relative to the index of processing cost (*RPCIL, RPDIL*) is an indicator of processor profitability.

With quantities canned and frozen combined for reasons noted previously, the grower raw-product pricing equations [(10a) replaces structural equations (10) and (12) and (11a) replaces structural equation (11)] are as follows:

(10a) $PGC = b_{70} + b_{71}QGCFN + b_{72}SCFRN + b_{73}RPCIL + b_{74}DCFNU2L + u_7,$

and

(11a) $PGD = b_{80} + b_{81}QGDN + b_{82}SDRN + b_{83}RPDIL + b_{84}DDNU2L + b_{84}D + u_8.$

The variables are more fully defined in tables 4 and 5. Imports are excluded from the lagged average movement values since, for pricing purposes, processors and growers are concerned mainly with projecting residual demand for U.S.-produced apricot products. The variable *D* in (11a) is to account for an apparent shift in price measurement for apricots used for drying beginning in the 1970s, as noted for the fresh price. The method of measuring the grower price for apricots for canning appears not to have changed.

The grower price system is completed by adding the quantity and price restrictions [re-

[9] Price found that in the period 1948–64 the per capita consumption of fresh apricots was significantly related to the price of California freestone peaches. We were unable to measure significant substitution relationships with other fresh fruits in the present data set. This may be due in part to the long-term trends in fresh consumption and the fact that annual observations for other fresh fruit extend beyond the months when apricots are available.

[10] An examination of the reported price series for apricots shows that differences between the deflated grower prices for dried and canned apricots and fresh and canned apricots averaged substantially higher from the mid-1970s onward compared to earlier years. This appears to be due to changes in price reporting and marketing practices. For example, fresh market prices are reported only for market-grade fruit, ignoring the large and variable quantities culled. In the case of dried apricots, there may have been some change in drying margin with the more extensive use of commercial dry yards.

Table 5. Additional Variable Identification for the Empirical Model

Variable	Definition
TSCFIN	.91*TSFN* + 31.25*TSCN* + 31.25*ICN*
Δ*PGC*, Δ*PGD*	*PGC* − *PGCL*, *PGD* − *PGDL*[a]
IPCE	Index of processing cost divided by the Personal Consumption Expenditure deflator, 1967 = 1 (see French and Willet, pp. 64, 65, 70)
Δ*IPCE*	*IPCE* − *IPCEL*
TAPN	Dried apricot production in Turkey and Australia, metric tons per 1,000 U.S. population
*PPD*2	.5(*PPD* + *PPDL*)
T	Trend, 1956 = 56, 1957 = 57, . . . , 1988 = 88
D	Binary variable, *D* = 0 prior to 1973, 1 thereafter
TC	*D*(*T* − 73)
SCFRN, *SDRN*	Stocks of canned and frozen (*CF*) and dried apricots (*D*) carried into the season, equivalent raw tons per 1,000 U.S. population
RPCIL, *RPDIL*	Previous-year values of *PPC*/*IPCE*, *PPD*/*IPCE*
DCFNU2L, *DDNU2L*	Previous-year values of two-year averages of U.S.-produced processed product movement per 1,000 U.S. population (*DCFNU* = *DCFN* − *ICN*, *DDNU* = *DDN* − *IDN*)

[a] An *L* suffix indicates a one-year lag.

placing equations (13) to (16) in the structural model] with quantities expressed relative to U.S. population:

(13a) $PGR - PGC = b_{90} + b_{91}D + u_9,$

(14a) $PGD - PGC = b_{100} + b_{101}D + u_{10},$

and

(15a) $QGN = QGRN + QGCFN + QGDN.$

The coefficients b_{90} and b_{100} replace the price differences, *MDR, MDD,* and *MDF,* in the structural model, and *D* is added to allow for the previously noted apparent change in price reporting beginning in the mid-1970s. Equations (9a) through (15a) form a six-equation simultaneous system in which the endogenous variables are *PGR, PGC, PGD, QGRN, QGCFN,* and *QGDN*; all others are predetermined in this block.

Estimation Results

Because the estimates of equation parameters may vary with the method of estimation as well as the model specifications, the equation systems were estimated by both Full Information Maximum Likelihood (FIML) and Two-Stage Least Squares (2SLS).[11] FIML is the more efficient method for simultaneous systems, but specification errors such as may appear in the time patterns of demand shifts may confound the estimates of other equations as well. Hence, 2SLS estimates are presented for comparison.

Processed Product Block Estimates

Initial estimates of the demand equation for canned-frozen apricots (1a) revealed the cross coefficient for dried apricots (*DDN*) to be near zero and not statistically significant. Further, when canned-frozen movement (*DCFN*) was included in the dried apricot demand function (2a), it, rather than *DDN,* was the dominant variable, with *DDN* only marginally significant. While *DCFN* may in fact be a better predictor of the dried apricot price (*PPD*), the statistical result appears to be mostly accidental due to the fact that *DCFN* was declining over time while the dried apricot demand (and *DDN*) shifted upward (see tables 1–3). In view of these results, the processed product demand functions were respecified with the cross-product terms deleted [*DDN* dropped from (1a) and *DCFN* from (2a)]. With this specification, the canned-frozen and dried apricot equations form separate simultaneous systems. To account for possible contemporaneous correlation of disturbances across the canned-frozen (*CF*) and dried demand (*D*) systems, the FIML estimates were applied to *CF* and *D* as one system. The 2SLS estimates, presented for comparison, were obtained separately for each system. The estimates of the processed product block are presented in table 6.

Referring first to the canned-frozen component (which has the best data and accounts for two-thirds of apricot production and con-

[11] The estimates were generated using SAS software, SAS Institute, Inc., Cary NC.

Table 6. 2SLS and FIML Estimates of the Processed Product Block

(1a) Canned-Frozen F.o.b. Processor Demand (*PPC*)

	Intercept	*DCFN*	*T*	*TC*	$(TC)^2$	*d*	R^2
2SLS	16.182	−.00648	−.0799	.0550	−.0039	1.50	.81
	(8.16)	(−7.11)	(−3.25)	(.54)	(−.67)		
FIML	16.273	−.00634	−.0832	.1284	−.0093	1.48	
	(10.39)	(−9.23)	(−4.07)	(1.47)	(−1.83)		

(2a) Dried Apricot F.o.b. Processor Demand (*PPD*)

	Intercept	*DDN*	*T*	*TC*	$(TC)^2$	*d*	R^2
2SLS	121.690	−.3477	−.3844	7.8303	−.3246	1.88	.78
	(2.69)	(−2.18)	(−.67)	(4.01)	(−3.01)		
FIML	122.893	−.3173	−.4275	8.2559	−.3676	1.85	
	(2.95)	(−2.26)	(−.80)	(4.23)	(−3.58)		

(3a) Canned-Frozen Market-Year Allocation (*DCFN*)

	Intercept	*TSCFIN*	Δ*PPC*	Δ*PGC*	Δ*IPCE*	*d*	R^2
2SLS	28.340	.7676	60.70	−1.0030	−7.6946	2.12	.96
	(1.12)	(23.20)	(2.11)	(−1.33)	(−1.76)		
FIML	47.099	.7411	102.394	−2.0385	−12.0720	2.33	
	(1.92)	(23.59)	(4.77)	(−3.62)	(−2.75)		

(4a) Dried Apricot Market-Year Allocation (*DDN*)

	Intercept	*TSDIN*	Δ*PPD*	Δ*PGD*	Δ*IPCE*	*d*	R^2
2SLS	−2.728	.8230	.3717	−.0014	−1.6562	2.35	.81
	(−.33)	(8.55)	(1.52)	(.03)	(−2.60)		
FIML	−2.739	.8230	.2978	.0187	−1.5051	2.38	
	(−.43)	(11.21)	(2.05)	(.57)	(−2.97)		

(8a) Dried Apricot Import Supply (*IDN*)

	Intercept	*PPD2*	*TAPN*	*d*	R^2
2SLS	−55.719	.4528	42.364	1.84	.77
	(−6.47)	(3.21)	(4.14)		
FIML	−55.8485	.5523	31.953	1.50	
	(−6.52)	(4.19)	(3.59)		

Note: Values in parentheses are *t*-statistics; *d* = Durbin-Watson statistic. For definitions of the variables, see tables 4 and 5.

sumption), all coefficients except for trend variables are large relative to their standard errors and are of expected signs. The trend coefficients indicate a continuing downward shift in the level of demand up to 1974. The 2SLS estimates of the coefficients for *TC* and $(TC)^2$ are not significant, suggesting a continuation of the historical downward trend beyond 1974. The FIML estimates of the *TC* coefficients, although not highly significant, suggest a short reversal of the trend in the mid-1970s, which becomes negative again in the 1980s. The estimate of the own-price coefficient for *DCFN* was not significantly affected by the method of estimation, nor was it affected much by altering the trend specification—for example, deleting *TC* and TC^2.

The canned-frozen market allocation equation (3a) indicates that with prices and costs unchanged, about 74–76% of the available supply has been marketed in the current marketing year, with the balance carried over. The allocations have increased with increases in price (Δ*PPC*) and decreased with increases in costs (Δ*PGC*, Δ*IPCE*), as was hypothesized. The FIML estimates suggest that the price and cost changes have had larger effects than do the 2SLS estimates, but all price and cost change coefficients are at least marginally significant with either estimation procedure.

Most of the parameter estimates of the dried apricot component are also large relative to their standard errors and have the expected signs, with the exceptions of the coefficients for T in (2a) and ΔPGD in (4a) which do not differ significantly from zero. The coefficients of the trend variables suggest there was little change in the level of demand up to 1974, as indicated in the Eryilmaz study. Demand then increased rapidly, but at a decreasing rate, leveling off and slightly decreasing after 1984. The estimates of the demand slope for dried apricots are similar under 2SLS and FIML.

Note finally that the model results indicate that the increase in dried apricot imports has been significantly associated with increases in the U.S. price and with the growth of apricot production in Australia and Turkey (primarily Turkey). The FIML and 2SLS estimates are similar, but with FIML giving relatively more weight to price changes and relatively less to foreign production changes.

Raw Product Block Estimates

Estimates of the grower-level fresh market demand equation and the processed product grower and dryer-level pricing equations are given in table 7. Although the equations leave substantial amounts of price variation unexplained (as indicated by the R^2 values), all coefficients except for the fresh market trend variables are large relative to their standard errors and are of the theoretically expected signs.

Note that the coefficients for pack and carry-in stocks in equations (10a) and (11a), both expressed in raw-product units or raw-product equivalents, are constrained to be equal. To test for possible differences in behavioral response to pack and carry-in stock levels, the model was first estimated with the pack and stock coefficients unconstrained. The 2SLS estimates of the coefficients for carry-in stocks (*SCFRN, SDRN*) were larger in absolute value than the corresponding coefficients for the pack variables (*QGCFN, QGDN*). However, the FIML estimates of the carry-in stock coefficients were less than the pack coefficients. In view of these inconsistencies, the hypothesis of different responses to pack and inventory levels was rejected and pack and stocks were combined into single seasonal supply variables, as indicated in table 7. The FIML estimates of the price-quantity coefficients, while similar in general magnitudes to the 2SLS estimates, are smaller in absolute value in the fresh market demand equation but larger in equations (10a) and (11a). The magnitude and significance of the time trend in the fresh market equation also vary with the estimation method. The FIML estimates are more efficient if the time shift specifications are correct.

Interpretation and Application

Potential users of the findings as presented in tables 6 and 7 may encounter difficulties because the specific right-side data needed for the conditional price predictions may not be readily available and, for more general forecasting purposes, the price and quantity predictions involve simultaneous solution of the equation systems. It is possible, however, to make some generalizations from these relationships which may be useful for planning purposes and to grower-processor bargaining agents.

Flexibilities and Elasticities

An important simplification is to express the price-quantity relationships as approximate percentage relationships. Table 8 presents price flexibilities and allocation and import supply elasticities for the Processed Product Block at mean and at 1988 values of prices and quantities. The price flexibilities are roughly consistent with the 1950–74 estimates by Eryilmaz of about −.43 for canned and −.24 to −.28 for dried apricots. The flexibilities below one suggest that processors are faced with elastic demands. The allocation elasticity may be interpreted as a short-run market supply elasticity where the total available supply is fixed. The allocation response is limited since marketings cannot exceed the seasonal supply.

Table 9 presents the price flexibilities at the means and for 1988 values of prices and quantities for the fresh market demand and the processed product price predicting equations based on the FIML estimates in table 7. The mean and 1988 fresh market flexibilities are similar. They suggest that the demand facing California fresh shippers is slightly elastic. This finding is consistent with findings of an early (1967) study by Price in which the fresh demand equation was estimated with quantity as the normalized variable. While, as noted previ-

Table 7. 2SLS and FIML Estimates of the Raw Product Block

(9a) Fresh Market Price (*PGR*)

	Intercept	*QGRN*	*T*	*TC*	$(TC)^2$	*D*	*d*	R^2
2SLS	478.89	−3,296.74	−1.9288	−13.005	1.0621	54.36	2.05	.60
	(2.20)	(−3.25)	(−.67)	(−1.40)	(1.86)	(1.37)		
FIML	690.85	−2,777.38	−5.6471	1.8396	.2737	71.07	1.88	
	(6.26)	(−5.71)	(−4.03)	(.46)	(1.16)	(3.38)		

(10a) Canning-Freezing Price (*PGC*)

	Intercept	(*QGCFN* + *SCFRN*)	*RPCIL*	*DCFNU2L*	*d*	R^2
2SLS	−34.83	−102.087	19.222	.142	1.76	.60
	(−1.07)	(−5.02)	(4.00)	(6.04)		
FIML	−10.37	−133.144	17.003	.157	1.69	
	(−.40)	(−7.65)	(4.45)	(7.48)		

(11a) Price at Dryers (*PGD*)

	Intercept	(*QGDN* + *SDRN*)	*RPDIL*	*DDNU2L*	*D*	*d*	R^2
2SLS	−22.15	−327.635	2.357	1.636	40.52	1.66	.63
	(−.37)	(−4.00)	(3.72)	(4.53)	(2.64)		
FIML	100.30	−482.72	1.674	1.039	24.42	1.52	
	(2.16)	(−4.98)	(3.08)	(3.46)	(1.76)		

(13a) Fresh Market-Canning Price Restriction (*PGR-PGC*)

	Intercept	*D*	*d*	R^2
2SLS	60.63	77.02	2.05	.41
	(4.89)	(4.46)		
FIML	62.51	73.38	2.05	
	(5.23)	(4.42)		

(14a) Drying-Canning Price Restriction (*PGD-PGC*)

	Intercept	*D*	*d*	R^2
2SLS	82.86	35.30	1.49	.37
	(13.39)	(4.10)		
FIML	84.48	32.15	1.48	
	(14.23)	(3.93)		

Note: Values in parentheses are *t*-statistics; *d* = Durbin-Watson statistic. For definitions of the variables, see tables 4 and 5.

ously, the processed product equations are not demand equations in the competitive model sense, the flexibilities less than one suggest that the grower-level processed product price response may also be elastic. The drying price elasticity is larger (flexibility smaller), as might be expected since the drying price reflects the added cost of drying.

Reduced Forms

Reduced form solutions for both processed product and raw product prices, with $T = 88$ and $D = 1$, are presented in table 10. The first two rows predict canned and dried product f.o.b. processor prices (*PPC, PPD*) as functions of the predetermined variables in the processed product block, and the next three rows predict grower-level prices for fresh market apricots (*PGR*), canning-freezing apricots (*PGC*), and apricots for drying (*PGD*, measured at the dryer level) as functions of the predetermined variables in the raw product block. The grower price equations differ only in the intercept values because of the imposed constant mean differences among prices.

The two columns at the right give the root-mean-square errors of the reduced form pre-

Table 8. F.o.b. Processor Price Flexibility and Elasticity Estimates for Apricot Products (Based on FIML Estimates, Table 6)

	Canned-Frozen		Dried	
	1957–88 Mean	1988 Value	1957–88 Mean	1988 Value
Price[a]	6.76	7.41	87.86	110.76
Movement (per 1,000 U.S. population)	553.16	243.14	65.42	70.59
Imports (per 1,000 U.S. population)	.26	1.08	18.60	53.94
Price Flexibility of Demand	−.52	−.21	−.24	−.20
Allocation Elasticity	1.25	3.12	.40	.47
Import Elasticity	not measured	not measured	2.61	1.13

[a] Specific price, movement, and import variables are *PPC, DCFN, ICN* for canned-frozen and *PPD, DDN, IDN* for dried apricots. See section on data and table 4 for further definitions.

dictions in actual values and relative to the means of the prices. The RMSE values indicate that the grower price predictions are subject to relatively greater error than the processed product price predictions, and prices for the dominant canned component are predicted more closely than the dried and fresh market prices.[12]

Since much of the input data needed for future price predictions may not be readily available to possible users, some further interpretation of the reduced-form coefficients may enhance the usefulness of the estimates. Referring to the *PPC* equation, each increase of 100 pounds of canned-frozen product supply per 1,000 U.S. population, with other variables constant, has decreased the canned product price by about 29¢ per case of 24 No. 2½ cans in 1967 dollars or 90¢ in 1988 dollars. Expressed in terms of cases (31.25 pounds of apricots), an increase of one case per 1,000 U.S. population has reduced the price by about 9¢ per case (28¢ in 1988 dollars), and vice versa. Put still another way, with the U.S. population at the 1988 level of 246.2 million, each change of 100,000 cases of total supply changes *PPC* by 3.62¢ in the opposite direction (11.4¢ in 1988 dollars). In percentage terms, the price flexibility at the mean with respect to canned-frozen supply is about −.3.

The dried fruit equation (*PPD*) may be interpreted similarly. An increase of 10 pounds of U.S. dried apricot supply per 1,000 U.S. population, with other variables constant, has reduced the f.o.b. packer price by about 4.5¢ per pound (14.1¢ in 1988 dollars). With U.S. population at the 1988 level, a one-million pound increase in U.S. dried apricot supply reduces the price by 1.8¢ per pound (5.7¢ in 1988 dollars). The price flexibility with respect to dried supply at the 1958–88 means is about −.17. An increase in Australia-Turkey apricot production of .1 metric tons per 1,000 U.S. population (about 25,000 tons at the 1988 U.S. population level) has been associated with a

[12] Further 1989 and 1990 out-of-sample prediction tests were restricted because of incomplete data when this was written and one key variable, canned carry-over stocks, is no longer reported. Out-of-sample predictions for 1987 and 1988, based on estimates utilizing data for 1956–86, were generally within acceptable confidence intervals (see Data section).

Table 9. Raw Product Price Flexibility Estimates (Based on FIML Estimates, Table 7)

	Fresh Market		Canning-Freezing		Drying	
	1957–88 Mean	1988 Value	1957–88 Mean	1988 Value	1957–88 Mean	1988 Value
Prices[a]	200.66	198.10	99.58	82.59	199.97	221.84
Quantity[a]	.0480	.0512	.6284	.2592	.1982	.1197
Price Flexibility	−.66	−.72	−.84	−.42	−.48	−.26

[a] Specific price and quantity variables are *PGR, QGRN* for fresh; *PGC, QGCFN* + *SCFRN* for canning-freezing; and *PGD, QGDN* + *SDRN* for dried. See section on data and tables 4 and 5 for further definitions.

Table 10. Reduced Form Equations for Prices Received by Apricot Processors and Growers, $T = 88$, $D = 1$, FIML Estimates

F.o.b. Processor Prices

	Intercept	*TSCFIN*	*TSDN*	*PPCL*	*PPDL*	ΔPGC	ΔPGD	$\Delta IPCE$	*TAPN*	RMSE[a]	RMSEP
PPC =	5.151	−.00285		.3936		.0078	.0464			.351	.052
PPD =	121.598		−.4477		.0192		−.0051	.4094	−7.1524	8.160	.092

Raw Product Prices

	Intercept	*QGTSN*[b]	*RPCIL*	*RPDIL*	*DCFNU2L*	*DDNU2L*	RMSE	RMSEP
PGR =	137.646	−100.58	12.8445	.3488	.1186	.2165	45.544	.228
PGC =	1.756	−100.58	12.8445	.3488	.1186	.2165	17.178	.173
PGD =	118.386	−100.58	12.8445	.3488	.1186	.2165	22.503	.112

Note: See tables 4 and 5 for variable definitions.
[a] RMSE is the root-mean-square error for 1957–88 predictions with *T* and *D* variable; RMSEP expresses RMSE as a proportion of the mean price.
[b] *QGTSN* = *QGN* + *SCFRN* + *SDRN* = total annual production (*QGN*) plus carry-in of canned, frozen, and dried apricots in raw-product equivalents, per 1,000 U.S. population.

.71¢ per pound reduction in the U.S. price (2.24¢ in 1988 dollars).[13]

At the grower level, a change in total apricot supply (*QGTSN*) of .1 tons per 1,000 U.S. population (about 25,000 tons with 1988 population) changed all raw product prices inversely by about $10 per ton ($31.60 in 1988 dollars). Because of the seasonal nature of the fresh market, the variance of the grower-level fresh-canning price difference has been large, as is the RMSE of the *PGR* prediction. Hence, it may be reasonable for some purposes to treat the quantity allocated to the fresh market as predetermined. In that case, equation (9a) in table 7 may be the preferred predictor. The FIML estimates indicate that a change of .01 tons per 1,000 U.S. population in the fresh market (2,500 tons at the 1988 U.S. population) has changed the grower price inversely by about $28 per ton ($88 in 1988 prices). The price flexibility estimates are given in table 9.

Summary Comments

The empirical findings support the behavioral hypotheses about the apricot demand system. With minor exceptions, the standard errors are small relative to the equation coefficients and the coefficient signs are consistent with theoretical expectations. A less positive result is that the statistical analysis leaves a substantial amount of price and quantity variation unexplained. Further, the magnitudes of some of the estimates of demand slope coefficients may be somewhat sensitive to the method of accounting for demand shifts associated with difficult to measure changes in consumer behavior, and the estimates of some coefficients vary with the method of estimation and the associated stochastic assumptions. Thus, although the estimates strongly pass tests of significance under all specifications and estimation methods, the individual tests may have limited value in establishing meaningful confidence intervals for the demand slopes or flexibility estimates.

While users of these demand estimates need to be aware of the limitations of the findings, the analysis nevertheless reveals a substantial amount of information about the demand structure for apricots. We would expect the estimates of price flexibilities and the simplified interpretation of price-quantity relationships to be useful to groups concerned with tariff policies, bargaining with respect to grower prices for apricots used for processing, and anticipating the price effects of changes in crop size, inventories, and product allocation.

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[13] Note that *TAPN* affects *PPD* through the effect on dried imports (*IDN*) which is endogenous in the system. If a given quantity of imports is placed immediately on the market (included in *DDN*), the effect is as indicated in equation (2a), table 6. For example, an increase in imports of 10 pounds per 1,000 U.S. population (about 2.46 million pounds at 1988 population levels) reduces the U.S. price by 3.17¢ per pound (about 10¢ in 1988 dollars).

References

American Institute of Food Distribution. *The Food Institute Report.* Fair Lawn NJ. Weekly, various issues.

Apricot Producers of California. *Annual Calendar and Statistical Report.* Modesto CA, 1990.

Eryilmaz, A. "An Econometric Analysis of the California Apricot Industry." Ph.D. Dissertation, Department of Agricultural Economics, University of California, Davis, 1978.

Federal-State Market News Service. *Marketing California Apricots.* Sacramento CA: California Department of Food and Agriculture. Various annual issues.

———. *Marketing California Dried Fruit.* Sacramento CA: California Department of Food and Agriculture. Various annual issues.

French, B. C. "Farm Price Estimation When There is Bargaining: The Case of Processed Fruit and Vegetables." *West. J. Agr. Econ.* 12(1987):17–26.

French, B. C., and G. A. King. "Demand and Price-Markup Functions for Canned Cling Peaches and Fruit Cocktail." *West. J. Agr. Econ.* 11(1986):8–18.

French, B. C., and L. S. Willet. *An Econometric Model of the U.S. Asparagus Industry.* University of California, Giannini Foundation Res. Rep. No. 340, 1989.

Helmberger, P. G., and S. Hoos. *Cooperative Bargaining in Agriculture: Grower-Processor Markets for Fruits and Vegetables.* Department of Agricultural and Resource Economics, University of California, Berkeley, 1965.

Judge, J., Inc. *Directory of the Canning, Freezing, and Preserving Industry.* Westminster MD. Various annual issues.

Kuznets, G. M. *Pacific Coast Canned Fruits F.O.B. Price Relationships, 1980–81.* University of California, Berkeley, Giannini Foundation, 1981.

Pacific Fruit News. Copperopolis CA: Frank Crawford, editor and publisher. Weekly, various issues.

Price, D. W. *The Marketing Order for Washington Apricots.* Washington Agricultural Experiment Station, Tech. Bull. 56, 1967.

U.S. Agricultural Statistics Board. *Noncitrus Fruits and Nuts.* Washington DC: U.S. Department of Agriculture, National Agricultural Statistics Service. Various annual summaries.