ECONOMETRIC ESTIMATION OF FARM PRICES OF PROCESSED FRUITS AND VEGETABLES: DOES IMPERFECT COMPETITION REALLY MATTER?

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ABSTRACT

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The markets for many processed fruits and vegetables are characterized by few processors and by market control programs or bargaining organizations on the supply side. Under such conditions, farm level demand functions may not be uniquely specified. This paper develops an approach to econometric estimation of farm prics when there is bargaining, with an application to the cling peach industry. For prediction purposes, the model turns out to be the same as would be obtained if the industry were misspecified to be perfectly competitive. However, proper specification may be important if the results are used for policy analysis.

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Many processed fruits and vegetables are produced by relatively small numbers of firms--if not nationally, at least locally. For example, in California, in 1984 only nine firms canned peaches, three canned apricots and only two or three canned asparagus. For commodities where there are more processors, the industry still may be dominated by one or two large firms. Similar concentrations are found for frozen and dried fruits and vegetables. When there are few processors there is at least some likelihood that raw product procurement may be characterized as oligopsonistic rather than competitive.

On the supply side, efforts of farmers to influence prices through marketing order programs and bargaining associations add to the imperfections of the grower-processor market. Volume-control marketing order programs are currently in effect for approximately ten fruit, nuts and vegetable commodities that are storable or used for processing.[1] In 1982 there were 10 fruit and 19 vegetable bargaining associations in the United States, 18 of the 29 located in the Western States of California, Oregon, and Washington (Skinner).

The existence of imperfectly competitive market structures may create difficult problems for the researcher interested in estimating the relationship between farm price and farm output. A unique farm level demand curve for a raw product cannot be specified for oligopsony since, as in the

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[1]Volume management programs under Federal marketing order apply to cranberries, tart cherries, California almonds, dates, raisins and prunes, Oregon-Washington filberts, Far West spearmint oil, Pacific Coast walnuts, Idaho, Washington, Oregon, and California hops. (USDA, ERS 477). In past years volume management programs for cling peaches and Brussels sprouts for freezing were operated under California marketing order legislation.

case of monopsony, each firm may take account of how its procurement price is affected by quantity purchased (see, for example, Miller, p. 371). Further, each processing firm may also take account of the reactions of its rivals, with many behavioral specifications possible. The existence of cooperative processors may provide a mixture of competitive and oligopsony behavior. It may be argued, however, that processing co-ops tend to be followers in an oligopsony setting (Just and Chern). When volume control programs are in effect, the decision process of the farmer marketing board also becomes a part of the model structure. And when there is farmer bargaining, equilibrium outcomes possibly may be defined only within some range of values.

This paper briefly reviews some approaches to modeling commodity input markets that depart significantly from the competitive case, illustrates a particular model with data for the cling peach market, and compares the results with estimates made under the misspecification that the market is competitive.

Farm Level Demand Under Oligopsony

Oligopsony embraces a broad class of market structures and there are no generally accepted behavioral assumptions, particularly no universal assumptions concerning reactions of rivals. One prominant class of behavior is price leadership. Using this specification, Just and Chern formulated a structural model of oligopsony for the California tomato industry where processors are believed to follow leadership pricing as a policy. Grower-processor contracts are signed prior to planting so farm price and quantity produced are jointly determined. Assuming competitive behavior on the supply side, Just and Chern showed that with parallel shifts in the supply curve (slope of supply curve constant), market observations of prices and quantities trace out what they called a "perceived demand curve." This curve falls below the demand curve that would face farmers if processors behaved as perfect competitors. If the slope of the supply curve changes, the slope of the perceived demand curve is altered.

The Just-Chern model establishes a structural relationship between farm price and quantity which can be estimated jointly with the supply function by using data for periods in which the slope of the supply curve and the price leadership practice remain unchanged. The functions estimated in this case may be econometrically indistinguishable from the functions that would exist under conditions of perfect competition--i.e., they would include the same variables. To test their behavioral hypotheses, Just and Chern estimated perceived demand functions for two separate periods (before and after the adoption of mechnical tomato harvesting) where they believed the slope of the supply curve had changed. They found that their estimate of the slope of the perceived demand curve also changed in a manner consistent with the change in the supply curve. Hence, they concluded that their model was a reasonable representation of processor behavior.

The modeling problem becomes more difficult if alternative oligopsony structures are posited or if the extent of price leadership varies over time. Further, if supplies are predetermined for a particular year, as in the case of tree crops, the textbook monopsony or oligopsony apparatus may not apply. Farm prices still could be depressed below the level of the processors' marginal revenue product curves (including storage costs), but longer term supply response might be considered by processors. This may be a fruitful area for further modeling efforts.

Farm Price Determination Under Market Control Monopoly

Although the decision system of a marketing board becomes part of the economic structure when there is a farmer-controlled volume management program, it does not necessarily present a difficult econometric problem. To illustrate, a study of the California cling peach industry found that the surplusing decisions of the Cling Peach Advisory Board could be predicted with considerable accuracy by relating the quantity allocated for sale to canners to potential on-tree production, last year's farm price, last year's quantity sold to processors, carryover stocks of canned peaches and fruit cocktail, exports, and the presence or absence of special tree removal incentive programs (Minami, French, and King). Since all the explanatory variables in the Control Board decision function were predetermined, the equation was estimated independently of raw product demand considerations. It is possible, however, that for other commodities subject to volume regulation, the Control Board decisions may be determined simultaneously with the farm price, thus requiring a simultaneous equation estimation procedure.

Farm Price Prediction Under Bargaining

Modeling the farm price determination process becomes more complex and difficult when farmer bargaining is introduced. The outcomes of bargaining negotiations (bilateral oligopsony?) are influenced by factors such as the industry share of sales represented by the bargaining association, the degree of competition among processor-buyers, the values of demand and supply elasticities, and less tangible factors relating to bargaining strategies.

Previous Work

A theoretical framework for evaluating the potential for farm price enhancement under various bargaining structures was developed by Helmberger and Hoos about 20 years ago. In later papers, Babb, Belden and Saathoff analyzed factors that affected the outcomes of the bargaining process in a specific setting and Ladd developed a model of bargaining behavior which he used to develop first-order equilibrium conditions for cooperatives with alternative objective functions. In a somewhat more historical and literary analysis, Bunje has described the strategies, tactics and procedures of bargaining and price negotiations based his many years of experience as bargaining association manager. While these studies provide insights into the bargaining process and the possible benefits and costs, they do not directly provide a framework for the econometric model builder interested in predicting annual price outcomes when there is an active bargaining process.

A Model for Processed Fruit Commodities

Although bargaining associations typically represent only a portion of industry tonnage, observations suggest that the outcomes of their negotiations with processors tend to set the farm price level for the industry. A key characteristic of this bargaining is that equilibrium price outcomes may be definable only within some range, rather than as intersections of supply and demand curves. The specific location of the final price is determined by factors pertaining to bargaining strength and strategies. To form a price prediction model we need first to specify the variables that influence the range within which bargaining occurs and second, to specify variables that affect the location of the negotiated price within the bargaining range.

To specify the bargaining range, it is reasoned that the maximum price processors would be willing to pay for the farm input is the price that returns zero expected profits. This is the expected f.o.b. price of the processed product less the expected processing and storage cost per unit, converted to raw product equivalents. The minimum grower price for a commodity such as tomatoes, where quantity supplied and farm price are determined simultaneously, is determined by the short-run grower supply curve. For a fruit crop where the quantity supplied is predetermined by the existing acreage and random yields, possibly modified by the surplusing decisions of a control board, the minimum acceptable grower price is likely to be proportional to production cost per unit. However, a precise specification of the minimum price is not necessary in this case.

As an analytical convenience, the location of the negotiated farm price within the bargaining range may be defined in terms of its deviation from the maximum price acceptable to processors. This difference may be viewed as the anticipated processor profit margin per ton of raw product (APPM) after the farm price has been settled. The farm price then may be expressed as the identity

(1) $PF = k(EPP - EPC) - APPM$

where PF as the farm price per ton, k is cases of processed product per ton of raw product, EPP is the expected f.o.b. price per case of product produced from the purchased farm product, and EPC is the expected processing cost per case. The expected f.o.b. price seems likely to be related to the quantity of raw product processed, the beginning stocks carried from the previous year and various indicators of the level of demand such as population, income, last period price and trends in consumption. The expected processing cost per unit

(EPC) may be closely related to some measure of actual processing cost and perhaps to the annual processing volume.

The anticipated profit margin (APPM) may vary with changes in market structure and variations in bargaining strategies. Changes in market structure might be measured by variables such as the share of industry tonnage marketed through the bargaining association. If the structure has not changed appreciably over the period of analysis, APPM might be regarded as a random variable that fluctuates with variations in market strategies and other individually minor market variables.

One additional variable that seems likely to affect the size of APPM is level of seasonal supply--i.e., quantity processed plus previous year stocks carried over. When the seasonal supply of processed product is relatively small, the maximum price acceptable to processors will be high and that will tend to bring the farm price up. But with relatively small production it seems likely that canners may attempt to achieve larger profit margins per unit of product in order to maintain total profit levels when volume is reduced.[1] Also, when prices are high growers may be less aggressive in attempting to squeeze additional returns from processors. When the seasonal supply is relatively large, on the other hand, processors may be willing to settle for a smaller anticipated profit per unit on the larger quantity, while growers become increasingly resistant as prices approach or fall below breakeven levels. Hence, the bargaining negotiations may result in a lower value of APPM when seasonal supply is large.

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[1]This could be offset to some extent if the competition among processors for limited supplies was strong. With relatively few processors that may not be a major factor.

With appropriate substitutions for the expected and anticipated variables in equation (1), the farm price predicting equation may be specified to include variables such as the following:

(2) $PF_t = f(QPN_t, SN_t, IN_t, PP_{t-1}, PCI_t, M_t, u_t)$

where PF is farm price per ton, QPN is quantity of raw product processed, expressed per capita, SN is stocks carried in from the previous year, expressed in raw product equivalents per capita, IN is an index of U.S. per capita disposable income, PP is the f.o.b. processor price of per case, PCI_t is an index of processing cost, M represents variables included to account of shifts in the structure of demand and u is a disturbance term.

Cling Peach Industry Estimation Results

Estimates of equation (2) for the California cling peach industry are presented in Table 1. The two equations provide different ways of dealing with a problem of high intercorrelation between a processing cost index (PCI, computed by the author) and per capita disposable income, as explained later.

For estimation purposes, the equation was expressed as a linear function except that the quantity variables, QPN, SN and IN were in logs. The latter was for consistency with logarithmic estimates of the canned product demand functions facing processors, which were developed as a component of a larger study. QPN is expressed in tons per million U.S. population, SN is stocks of canned peaches and fruit cocktail as of June 1, expressed in raw product equivalent tons per million U.S. population, IN is an index of U.S. per capita disposable income (1967 = 100), and PP is f.o.b. canner price per case of 24 No. 2-1/2 cans.

Table 1. Cling Peach Farm Price Prediction Equations.[a]

(Ordinary Least Squares, 1956-57 to 1981-82 data)

Equation	Constant Term	ln QPN	ln SN	ln IN	PP_{-1}	PCI	D74	T19	T14	R^2	DW	S
(2a)	619.5530	-56.2956	-19.1229	64.1237	6.9697		34.1177	9.5456	-12.6982	.973	1.56	6.9149
	(172.2000)	(18.4757)	(5.3060)	(13.5066)	(3.2168)		(11.3609)	(2.9820)	(3.9988)			
(2b)	717.1960	-58.0670	-20.8885	105.7770	14.0868	-1.0632	35.5611	22.4350	-11.1771			
	(271.5490)	(29.1345)	(8.3672)	(21.2987)	(5.0726)		(17.9152)	(4.7024)	(6.3058)	.934	1.32	10.9042

[a]The dependent variable for both equations, as written, is PF. However, equation (2b) was estimated with the dependent variable expressed as PF + 1.0632 PCI. The value of R^2 with respect to PF + 1.0632 PCI is .993. Values in parentheses are standard errors, DW is the Durbin-Watson statistic and S is the standard error of the regression. The first observation on the dependent variable is 1957 due to the lagged value of PP.

Variable identification:

PF = farm price per ton
QPN = quantity of raw product processed, expressed per capita
SN = stocks of peaches and fruit cocktail carried in from the previous year, expressed in raw product equivalents per capita
IN = index of U.S. per capita disposable income
PP = f.o.b. processor price of canned peaches, dollars per case
PCI = index of processing cost (1967 = 100)
D74 = dummy variable: 0 from 1956-1973, 1 from 1974 on
T19 = trend variable: T19 = 0 up to 1974, T19 = T-19 from 1974 on (T = 1 in 1956)
T14 = trend variable: T14 = 0 up to 1969, T14 = T-14 from 1969 on (T = 1 in 1956)

The variables T14, D74 and T19 replace M in equation (2). Observations of the industry data suggest there have been at least three important changes in the structure of demand since the decade of the 1960's. First, there appeared to be a general downward trend in per capita demand for conventional canned fruits beginning about 1970. The variable T14 was introduced to account for this effect. It has a value of zero prior to 1969 (year 14 in the data set) and is T minus 14 thereafter, where T = 1 in 1956 (first year of data set).

Second, the accelerated rates of inflation and concerns for energy shortages following the Arab oil embargo appeared to shift the structure of prices upward as part of what might be viewed as a new inflationary psychology. D74 was introduced to account for this shift. It has a value of zero prior to 1974 and is 1.0 from 1974 onward through the remainder of the data set (until 1981).

Finally, another trend variable (T19) was introduced to allow for possible further shifts in price structure following the initial shift which seemed particularly evident in 1974. T19 has a value of zero prior to 1974 and is T minus 19 thereafter (T = 19 in 1974). A variable to reflect changes in bargaining structure was not included since it appears to have been fairly stable. The effects of other changes in competitive structure are likely to be absorbed by the artifical variables T14, T19, and D74.

Without any constraints, the estimated coefficient for PCI is positive (when it should be negative) because the undeflated income (purchasing power) effect of IN dominates the effect of increased processing cost. Deflating by the Consumer Price Index did not solve the problem; in that case, the effect of PCI became statistically nonsignificant.

Equation 2a in Table 1 deals with the intercorrelation problem by simply deleting PCI as an explanatory variable. The coefficient for ln IN then reflects the combined (and partially offsetting) effects of both variables. This has little effect on the historical accuracy of the farm price prediction. Nor would it have much effect in the future if we could be certain that PCI and IN would continue to be related as in the past. However, if that relationship were to change, then the predictions might be subject to biased error.

Equation (2b) presents a second approach in which a value for the PCI coefficient (b_5) is imposed from another source. A processor price-markup equation, estimated as another component of the total commodity system, provided an estimate of the effect of a change in the processing cost index (PCI) on the f.o.b. processor price of canned peaches (PP). This was converted to an equivalent effect on farm price by multiplying by the mean processed product conversion ratio of 52.89 cases per ton, giving a value of 1.3487. The latter was constrained to be negative in the farm price equation. Since the prior estimate is subject to error, the constraint on b_5 was imposed as $b_5 = -1.3487 + u$, $var(u) = .00906$. The variance of u was obtained from the standard error of the coefficient for PCI in the price-markup equation.

Equation (2b) was first estimated using the Theil-Goldberger mixed estimation approach. However, this led to a rejection of the constraint because of the opposite signs imposed and high positive association of PCI and IN. Therefore, the procedure finally followed was to impose fixed-value restrictions on b_5 within a range of ± three standard deviations, choosing the result with the least sum of squared residuals. A value three standard errors below the value of 1.3487 (1.0632) provided the best predictor.

The results in Table 1 indicate that with the exception of the intercorrelation problem with PCI, all coefficients have signs consistent with theoretical expectations, and are large relative to their standard errors. The values of the Durbin-Watson statistic fall in the indeterminant range. It might be noted that the coefficients of QPN and SN are a result of both negative effects of lower expected product prices with larger volume and, under the hypothesis, the positive effect of reduced processor profit per unit. Hence it is theoretically possible that the coefficients could be very small and statistically nonsignificant, although it seems likely that the positive APPM effect would dominate. While the specific manner in which the artificial variables were imposed to account for structural shifts and the constrained coefficient for the PCI variable might be debated, the equations perform well with respect to historical price predictions.

Concluding Comments

Note that the variables involved in the price predicting equation are the same as would be included in a farm level demand function under perfect competition. This suggests an interesting and significant conclusion. Even if the structure of the model had been misspecified to be purely competitive, the same equation would have been estimated. The fact that it would have been incorrectly identified as a demand function, would not alter the price predictions. Conversely, if processors actually behave as perfect competitors and if the bargaining results do not depart signficantly from the competitive result, the equation estimated approximates a farm level demand function. Hence, even though the uncertainties of competitive behavior may cause some uncertainty as to what has actually been measured, the price predictions would be the same.

How far one can generalize from this specific model is not clear. But it suggests, at least in cases similar to this one, that if we are interested primarily in prediction and there are no significant structural changes which would affect APPM, misspecification of the competitive structure may have little effect on what is estimated. However, if such estimates are used to evaluate welfare implications of particular programs, proper specification may be very important. It is also important to note that evaluating the full effect of some policy that would affect the quantity produced requires a dynamic model of the entire system, not just a single period price prediction equation.

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