A MODEL OF WEEKLY PRICE DISCOVERY FOR FLORIDA CELERY

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Considerable attention has recently been paid (Rhodes, Tomek and Robinson) to the various alternative mechanisms for discovering prices of agricultural products. Alternative mechanisms include organized markets and auctions, individual price negotiations, group bargaining, supply-demand estimation pricing, and formula pricing. One such price discovery mechanism is currently employed by the Florida Celery Exchange, a voluntary marketing cooperative which represents all major Florida celery producers in setting prices. The role and performance of the Exchange in influencing weekly Florida celery harvesting and pricing decisions are of particular interest because the Exchange's price-fixing activities represent, at least *a priori*, a departure from the traditional competitive price determination process.

Recent work in the economics of information illustrates the uncertainty faced by firms and the implications of market structure on price determination and price dispersion (Grossman and Stiglitz, Kirman, Salop). It has been observed that price equilibrium conditions and the informational value of prices depend largely on how information is transmitted and collected (Garbade et al.). The costs associated with the collection and analysis of information concerning a market or commodity reflect an expenditure of resources. If prices are widely dispersed in an imperfectly competitive market, buyers of inputs may lose market opportunities if they purchase inputs at higher prices than their competitors. Thus, there may be substantial returns to buyers who incur search costs in such markets. Despite relatively available and costless information, even fairly competitive markets may yield significant price dispersion (Pratt et al.).

One criterion for evaluating the performance of the pricing methods employed by the Exchange is the closeness of actual weekly price patterns to those expected to prevail given approximately competitive equilibria.[1] To provide such an evaluation, we first analyze the physical, institutional, and economic forces which shape celery harvesting and pricing decisions and second formulate a structural econometric model to represent the dynamic competitive operation of the market.

OPERATION OF THE FLORIDA CELERY EXCHANGE

Florida celery production is concentrated in three counties, and a dozen growers account for more than 90 percent of the state's celery marketings during a crop year. Over the last 10 years, Florida celery shipments have comprised about 42 percent of total U.S. celery supply during the November to June season, the remaining quantities being supplied by California (Florida Dept. of Agriculture). California's share of the winter-spring celery market, however, has been steadily increasing in recent years.

Florida celery matures from field set plants between 70 and 110 days after planting.[2] Unlike that of many fresh vegetables, the timing of celery harvesting is flexible within weekly bounds, and the total amounts harvested within a given week are not necessarily marketed because short-term storage is possible. Most celery shipments go directly to retail outlets, although wholesale celery markets do operate in large metropolitan areas (Mathis and Degner). Thus, as with other Florida winter vegetables, the price-setting process has shifted from the wholesale level terminal to the production-shipping point (Bohall).

Approximately 95 percent of celery marketings are overseen directly by the Florida Celery Exchange, a voluntary marketing cooperative which represents all major Florida celery producers. Members pass complete market control over their celery to the Exchange by

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The authors are indebted to Angelos Pagoulatos, and Robert Sorensen, and three anonymous reviewers for helpful comments.

[1]Several other criteria have been suggested (Tomek and Robinson) for evaluating the performance of alternative price-making institutions. For example, one could ask how well a particular pricing system performs in contributing to price stability or in reducing the search costs of information.

[2]For a detailed description of the Florida celery industry, see Rose.

means of contracts.[3] The Exchange constantly monitors market developments, growing conditions, and daily production of both Florida and California celery.[4] Then, in an effort to maintain stable weekly markets, the Exchange usually sets a Florida FOB celery price on each Monday and Wednesday morning. Infrequently, prices are changed on other days during the week to accommodate rapidly occurring market developments. If prices are lowered on such occasions, buyers are given price protection for purchases made subsequent to the last price quotation. Thus, on a week-to-week basis, Florida celery price levels and shipments reflect the operation of the Celery Exchange.

More specifically, the Exchange sets non-negotiable prices for the major size categories of celery that are expected to clear the market on the basis of information collected on both supply and demand conditions. On the supply side, the manager of the Exchange uses information on recent harvestings, sales, and inventory levels of member celery producers along with projections of production, weather conditions, and labor availability for the entire week. On the demand side, the manager elicits information from various sources concerning the number of new buyers in the market, changes in size and frequency of orders, as well as information on current California market conditions. If unforeseen changes in Florida and California supplies or national demand conditions occur, the Exchange has the option to alter prices more often within the week to accommodate these changes. The possibility of adjusting prices to rapidly changing conditions implies that the Exchange makes great efforts to achieve a market clearing price.

THE HYPOTHESIZED MODEL

We propose that the price-setting process used by the Exchange nearly replicates the operation of a competitive market. The distinctive aspect of the operation of the Exchange is that quantities supplied and demanded, rather than prices, adjust to produce a market equilibrium. Breimyer (p. 116) uses the term "supply-demand estimation pricing" for a price discovery mechanism whereby a farmers' organization estimates what price best fits the current market situation.[5] The concern here is with the degree of market control available to the Exchange as it exercises its price-setting powers. The following discussion provides the justification for the selection of an econometric model of the Florida celery industry assuming a competitive market.

FIGURE 1. THEORETICAL MODEL OF PRICE DISCOVERY BY A COMMODITY EXCHANGE

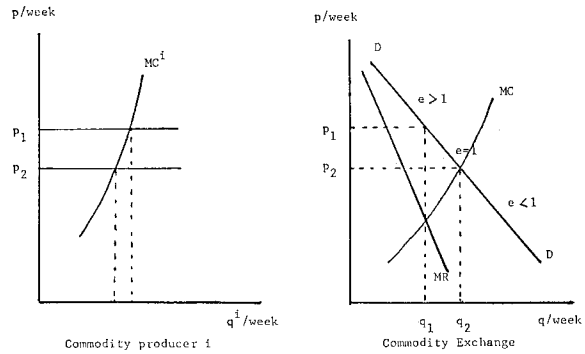

Figure 1 is a simple graphic representation of the price-setting alternatives available to the Florida Exchange. The celery Exchange assumes the responsibility, on behalf of a number of producers, of determining the selling price of a relatively homogeneous and perishable product. The Exchange sets non-negotiable product prices that can range within two limits. As a single selling agency, the Exchange may act as a profit-maximizing monopolist and thus set a price consistent with equality between marginal revenue and marginal cost (price p_1). At the other limit, the Exchange may be constrained by industry characteristics and external forces to a price at which industry demand and industry supply are equated (price p_2).

A joint selling agency such as the Exchange may not necessarily act as a monopoly for several reasons. First, the agency's prices may be undercut by sales of nonaligned rivals in other regions. Second, the agency may be constrained in the neighborhood of the perfectly competitive price if it faces buyers with substantial market power. These considerations are relevant to the Florida celery industry.

One immediate consequence of the nearly competitive market assumption requires that producers act individually and independently. Every producer receives a uniform price, regardless of his level of output, and his level of output is conditioned by current price. The individual producer therefore is a price taker —

[3]Since the Florida Celery Marketing Order was established in 1965, it has effectively barred new members from entering the industry. Entry control is exercised through annual marketing allotments issued to individual producers, based on a combination of a Base Quantity (or maximum number of crates that each can market) and the total amount of celery that should be marketed during the current season. In recent years, however, no intraseasonal restrictions have been imposed on marketings (Rose, Shonkwiler).

[4]The California celery markets has no institutions similar to the Florida Exchange. California celery production is divided among a few large integrated corporate firms and a large number of independent producers who market their crop through selling agents.

The implications of such a price discovery mechanism are that supply curves are relevant concepts in describing the market and that the set price actually acts to clear the market.

he faces a demand curve that is infinitely elastic (p_1 or p_2). A second consequence requires that no single structural price-setting equation exist. Rather, in a competitive market, price is determined solely through the interaction of supply and demand. We propose, in effect, that the Exchange operates as an "invisible hand" and achieves market clearing prices at nearly competitive levels.

How well such efforts succeed in approximating the weekly price patterns that would be likely under competitive equilibria is an empirical question. To test whether prices adjust sufficiently during the week to maintain balance between quantities supplied and demanded, a structural econometric model consistent with a competitive market is formulated to replicate the dynamic operation of the Florida celery market.

MODEL SPECIFICATION

In this section an econometric model is developed to represent the dynamic processes of production and price adjustment within the Florida celery industry. The model is dynamic in that current Florida conditions affect current and future levels of key variables; but because lagged California shipments and prices enter the model, these variables must be set at prespecified levels to analyze periods longer than a week. Thus, interpretation of other than impact (i.e., single period) multipliers or elasticities must be conditioned on these features.

The relevant producer price to which Florida growers respond is, to some extent, given by the Exchange. The celery price declared by the Exchange represents a parameter (rather than a variable) on which growers can base harvesting decisions. A relatively high current supply price may induce accelerated or more thorough harvesting of the celery crop, reductions of stocks, and thus larger marketings. Yet the crop base is essentially fixed for periods of less than three months, so a substantial limit to supply response must be imposed over the short-run. Our formulation of the supply equation includes both current and lagged price changes to account for the fact that the crop's perishability probably limits short-run response to a one- or two-week period. Because the supply model is dynamic, a number of interactions are possible over time. For example, the occurrence of higher prices during a particular week will result in supply increases that are manifested either through stock reductions or through accelerated harvesting. The result during the subsequent week is a supply reduction.[6]

Besides including average weekly prices in the supply equation, we add lagged celery production to capture partial production adjustments, and introduce two dummy variables to represent poor growing conditions during 1973 and 1976. To complete the specification, the influence of seasonality in production is represented by a low order polynomial in time within each season (Shonkwiler). The resulting supply equation is specified as:

$$(1) \quad Q_t = f_s(\Delta P_t, \Delta P_{t-1}, Q_{t-1}, S_t, S_t^2, D73, D76)$$

where

Q_t = Florida celery shipments in carloads during week t,
P_t = average Florida celery price in cents per 2-2½ doz. carton,
$\Delta P_t = P_t - P_{t-1}$,
S_t = weekly trend term for each season, second week in December is 1,
S_t^2 = S squared,
D73, D76 = dummy variables having values of one during 73 or 76 season and zero otherwise.

The quantity of celery demanded by wholesale and retail outlets is postulated to depend on the current Florida price, the amount of previous California celery marketings, prices received the previous Friday in California, and seasonal or annual variations in demand. The responsiveness of demand to short-run changes is generally constrained by the perishable nature of the commodity. That is, the relatively short interval between purchases and ultimate consumption limits adjustments to prices. Also, demand for Florida celery is discontinuous because commercial marketings do not begin until the late fall. Wholesalers and retailers therefore must make a decided changeover to the Florida product from alternative sources (Mathis and Degner). Thus, lagged levels of demand may be important indicators of how rapidly wholesalers and retailers begin handling Florida celery. The pace of the changeover is probably conditioned by custom and habit as well as other economic factors. This dynamic demand specification permits the elasticity of demand for Florida celery to increase over time as a result of adjustments to California marketings and demand substitution.

Because Brooke and Jung found that demand tended to erode toward the end of the marketing year, monthly dummy variables are used to capture this presumed seasonality. In addition, a variable representing the Christ-

[6]The importance of unsold celery stocks to price formation has been noted by Riggan and Brooke. However, data on the response of stock holdings to price changes were not readily available. The inclusion of lagged prices in the supply equation is expected to capture implicitly the impact of inventory additions or reductions.

mas holiday week is incorporated to account for interruptions in product distribution and demand. A yearly time trend is included in the demand specification to account for year to year shifts in consumption due to increasing population and incomes as well as changing preferences.[7] The postluated weekly demand equation is:

$$(2) \quad Q_t = f_d(P_t, Q_{t-1}, PC_{t-1}, QC_{t-1}, YEAR, DH, M_j)$$

where

PC_t = celery price in California on Friday of week t,
QC_t = total California celery shipments,
YEAR = annual trend term, 1972-73 season is year 1,
DH = dummy variable for Christmas holiday week,
M_j = dummy varible for j^{th} month (except March).

THE ESTIMATED MODEL

The weekly Florida celery price determination mechanism was analyzed by using 156 observations for six December-June marketing seasons (1972-73 through 1977-78). Table 1 shows the parameter estimates for the behavioral equations. Because of the postulated simultaneous nature of the structural model, three-stage least squares estimation techniques were utilized to provide asymptotically consistent and efficient parameter estimates. Calculated "t-values" are conditional in the sense that the desirable statistical properties of the estimation technique depend on large-sample behavior. For the supply and demand models, the calculated value of Durbin's h-statistic, which tests first order serial correlation in the presence of lagged dependent variables, is also presented. No evidence of statistically significant autocorrelation is found.

The estimated supply equation includes current and lagged price changes in an effort to capture short-run supply responsiveness and its rigidities. A 10 percent increase in current price causes about a 5 percent increase in supply. But a 10 percent increase in price the previous period calls forth a 2.5 percent decrease in current supply, reflecting the fact that stocks may have been reduced and harvesting accelerated in the previous period. Structural impact and interim mean elasticities of supply are presented in Table 2. The interim elasticities show that the supply effect of a price increase diminishes rapidly.

Coefficients on the weekly polynomials in time (S_t and S_t^2) suggest the celery production peaks about the twelfth week of the season each year. This finding corroborates the observed production peak in early spring. Apart from the calculated significance of the dummy variables D73 and D76, all other variables enter the supply equation at highly significant levels and with the expected signs.

The estimated demand equation shows that demand is inelastic at the producer-shipper level, a 10 percent price increase causing a 4.8 percent reduction in demand. Demand does be-

TABLE 1. STRUCTURAL AND REDUCED FORM ESTIMATION RESULTS

Variable	Structural equations: Supply	Structural equations: Demand	Derived reduced form: Q_t	Derived reduced form: P_t	Unrestricted reduced form: Q_t	Unrestricted reduced form: P_t
P_t	---	-.271 (3.62)[a]	---	---	---	---
ΔP_t	.282 (3.45)	---	---	---	---	---
INTERCEPT	71.5 (4.59)	-166 (.84)	-49.5 (.53)	-429 (1.42)	303 (1.55)	-620 (2.25)
P_{t-1}	---	---	-.138 (4.31)	.510 (6.99)	-.098 (2.39)	.461 (8.09)
ΔP_{t-1}	-.141 (2.69)	---	-.069 (2.76)	.256 (3.01)	-.207 (4.31)	.166 (2.48)
Q_{t-1}	.646 (10.3)	.529 (9.17)	.587 (11.7)	-.211 (1.95)	.493 (8.22)	-.163 (1.94)
PC_{t-1}	---	.200 (3.29)	.102 (3.78)	.361 (5.73)	.079 (2.26)	.416 (8.49)
QC_{t-1}	---	-.129 (3.83)	-.067 (3.94)	-.233 (4.02)	-.203 (5.21)	-.042 (.78)
S_t	8.74 (3.38)	---	4.28 (3.48)	-15.8 (3.48)	.284 (.06)	-7.12 (.82)
S_t^2	-.358 (4.03)	---	-.175 (4.07)	.647 (3.97)	-.974 (.36)	.365 (1.26)
YEAR	---	5.61 (2.00)	2.86 (2.17)	10.1 (2.41)	-.228 (.09)	10.4 (2.80)
DH	---	-36.6 (2.32)	-16.6 (2.42)	-66.1 (2.48)	-87.4 (5.08)	20.2 (1.17)
DEC	---	-3.20 (.20)	-1.63 (.21)	-5.79 (.21)	10.8 (.23)	-10.3 (.16)
JAN	---	-16.8 (1.52)	-8.55 (1.60)	-30.3 (1.63)	-18.1 (.67)	-12.0 (.32)
FEB	---	-8.47 (.86)	-4.32 (.89)	-15.3 (.89)	-26.4 (1.69)	17.7 (.81)
APR	---	4.86 (.48)	2.48 (.50)	8.79 (.52)	13.4 (.83)	10.7 (.47)
MAY	---	-41.1 (3.88)	-21.0 (3.83)	-74.4 (3.53)	-25.7 (.85)	-40.5 (.95)
JUN	---	-58.4 (4.16)	-29.8 (4.05)	-106 (3.63)	-45.4 (1.03)	-63.7 (1.02)
D73	-.37 (.04)	---	.181 (.04)	-.669 (.04)	-11.8 (1.20)	-22.7 (1.64)
D76	-14.4 (1.60)	---	-7.06 (1.60)	26.0 (1.64)	-16.9 (1.91)	18.5 (1.49)
h	-.64	.19				
R^2			.713	.936	.805	.951

[a]Numbers in parentheses represent the absolute value of calculated t-statistics.

TABLE 2. STRUCTURAL IMPACT AND INTERIM ELASTICITIES

Period	Impact elasticities[a]: Supply	Impact elasticities[a]: Demand	Interim elasticities[b]: Supply	Interim elasticities[b]: Demand
t	.501	-.481	.501	-.481
t+1	-.428	-.254	.073	-.735
t+2	-.026	-.135	.047	-.870
t+3	-.017	-.071	.030	-.941
t+4	-.011	-.038	.019	-.979

[a]Percentage change in quantities given a one-time change in price.
[b]Percentage change in quantities given a sustained change in price.

[7]Price determination during the weekly observation period is presumed to occur at the producer-shipper level. It is therefore not necessary to include consumer income, population, and prices of possible substitutes in the weekly demand function.

come less inelastic in the long run, as illustrated in Table 2. Of course, these structural elasticities represent only partial effects because for periods longer than a week there appears to be a strong relationship between the California and Florida markets. In fact, a 10 percent increase in either the previous week's shipments or the Friday price in California will respectively reduce demand by 2.1 percent or increase demand by 3.4 percent. This result confirms the importance of the California celery market in constraining the price-setting activity of the Florida Exchange.

Some seasonal factors enter the demand equation with high levels of significance. As expected, demand tapers off toward the end of the season (May and June). Otherwise, there are no other *a priori* notions about the magnitudes of the monthly dummy variables; their significance levels suggest little contribution to the equation. The dummy variable representing the Christmas holiday shows how demand drops from previous levels during that period. Finally, the coefficient on the annual trend variable is interpreted to show that, all other factors held constant, demand for Florida celery grows about 4 percent per year.

Table 1 also permits the comparison of the OLS estimates of the unrestricted reduced form with the restricted reduced form parameter estimates derived from the structural model. The results in Table 1 indicate the inverse relationship between prices and quantities in the reduced form. By and large, the unrestricted and restricted reduced forms correspond closely with respect to coefficient signs and relative magnitudes. Notable exceptions are the coefficients on QC_{t-1} in both the quantity and price equations. Essentially, the restricted reduced form discounts the importance of lagged California shipments to Florida shipments and shifts this effect to the Florida price variable. The effect of the weekly polynomial in time is much greater in the derived reduced form because this seasonality is more systematically introduced. Also, the dummy variable for the Christmas holiday, DH, reflects a depressing effect on both shipments and prices in the structural model's reduced form.

MARKET IMPLICATIONS AND CONCLUSIONS

The institutional description of the Exchange's price-setting procedures suggests a "supply-demand estimation" price discovery mechanism. Indeed, the fact that the competitive specification of our econometric model provides a good description of actual market behavior attests to the success of the price-setting scheme employed by the Exchange in equilibrating the quantities supplied and demanded. This success is rather remarkable, because the manager uses no explicit econometric model in setting prices (Shonkwiler).

A number of structural market characteristics for this industry, such as the limited number of producers, the control on prices exercised by the Exchange, and the virtual absense of entry, could lead one to expect the absence of competitive market forces. The available evidence, however, indicates that the overall outcome of the Florida celery market closely approximates the results obtained under competitive conditions. That is, the actual market data conform rather well to the specification adopted in our study, namely a model in which prices act to equilibrate supply and demand over the period under consideration. It is entirely possible that the effect of a single selling agency — a seemingly monopolistic organization — is to produce, paradoxically, a result apparently consistent with perfect competition.

This striking result is corroborated by some additional evidence. Given the inelastic demand facing Florida celery producers, the possibility of monopoly control on weekly prices by the Exchange has to be eliminated. It is a well known result of economic theory that a monopolist will restrict output to operate on the elastic portion of his demand curve. Finally, the Exchange may be constrained to a competitive outcome in its pricing decisions as a result of increasing competition from California growers. Not only has California's share in the winter celery market grown in recent years, but our empirical results also indicate that pricing decisions by the Exchange are strongly influenced by changes in previous California sales.

The Florida Celery Exchange's contribution to the provision of market information and price stability should be considered as well. In the absence of a marketing institution such as the Exchange, the presence of only a few sellers in the market with different amounts of information concerning market conditions may lead to oligopolistic interdependence and various forms of noncompetitive equilibria. The resulting market uncertainty may generate price wars and nonprice competition and lead to a misallocation of resources and price instability (Wu).

Certainly in a market with homogeneous, perishable commodity such as celery, instability seems more likely to occur in the absence of an institution such as the Exchange. And the cost of stability may be prices that are not much above the competitive norm. Wu (p. 70) states, "I suggest that while stable prices are found in conjunction with monopoly power, stable price itself does not necessarily lead to

inefficient allocation of resources." The results of our empirical analysis indicate that the Florida Celery Exchange provides a valuable information collection and interpretation system that probably yields stable prices at close to short-run competitive levels and substantially reduces buyers' search costs.

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