PRICE DETERMINATION AND ACREAGE ADJUSTMENT BEFORE AND AFTER THE IMPLEMENTATION OF A MARKETING ORDER

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ABSTRACT

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Price determination and planted acreage adjustments are evaluated before and after the installment of a marketing order in the Florida celery industry. The industry deviated from marginal cost pricing. However, current acreage planted was influenced by different factors before the marketing order than after.

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1. Introduction

The United States Congress authorized marketing orders in order to help farmers maintain orderly marketing conditions and achieve parity prices (Armbruster and Jesse 1983, p. 122). The influence of marketing orders on resource allocation is a national concern (U.S. Comptroller General 1985). Through the use of quantity controls, marketing orders may alter the operation of a market and affect the allocation of resources (Polopolus, et al 1986, p.18). However, the measurement of the allocation effect has been indirectly accomplished (e.g. Minami, French, and King 1979, Shepard 1986, Thor and Jesse 1981) and the credibility of the indirectness has been questioned (French 1982, Lucas 1976).

This article eliminates the suspect nature of such studies by using data from an industry before and after the implementation of quantity controls. The analysis is over a longer period of time (yearly data over a 33 year period unlike Thompson and Lyon), the implementation of the marketing order was not expected, and the intraseasonal (i.e., quantity marketed) and interseasonal (i.e., acreage changes) adjustments are explicitly modeled. Price determination and acreage adjustment before the use of quantity controls are compared and contrasted with price determination and acreage adjustment after the implementation of quantity controls.

2. Theoretical Considerations

A state celery marketing order in Florida was initiated in 1961 and declared unconstitutional in 1964. Since 1965, the Florida celery industry has operated under a Federal marketing order specific to Florida. Given the manner in which the celery marketing order functions, a complete theoretical model of the industry requires an industry profit function, an acreage determination function, a representation of the production technology for celery, an optimization rule, and specification of industry demand. Assuming the existence of a well defined cost function, the profit maximization problem for the industry may be stated as

$$\max_{y_t, a_t} [p_t * q_t - c(w_t, y_t) * a_t \mid q_t = q(p_t, z_t) \text{ and } q_t = y_t * a_t] \quad (1)$$

where p_t denotes the market price received by farmers; $q_t = y_t * a_t$ represents total quantity produced, which is explicitly defined as the product of yield per acre (y_t) and acres planted (a_t); c is the aggregate industry cost function; w_t is the input price vector for variable inputs other than land; and z_t is a vector of exogenous demand shift variables. Although the acreage planted (a_t) is endogenous to the model, it is exogenous to the determination of the final level of output and price. Under the marketing order planted acreage is determined before the season starts while yield is determined as the season progresses. The yield variation during the season alters the final output and price.

The first stage of production determination has the marketing order, through the actions of the Florida celery exchange, determining total Florida celery production. The marketing order composed of Florida's 15 celery producers (U.S. Department of Commerce) evaluates the supply and demand situation for Florida celery before the season starts and uses the quantity sold in the season just ended as a starting point in determining the quantity to be sold in the coming year. Florida producers have developed customers of long standing and must consider servicing these customers in the future. Furthermore, celery production requires specialized equipment which cannot be used in the production of other crops.

Because the actual yield for the upcoming season is unknown, the quantity set by the marketing order results in a certain number of acres planted by the industry based on expected yield. Acreage planted replaces the marketing order quantity in the following model. The outcome of the decision process used by the marketing order is assumed to follow a partial adjustment process. This may be accomplished by considering the traditional Nerlove model (Askari and Cummings 1977)

$$a_t - a_{t-1} = (\lambda_0+\lambda_1 D)(a^*_t - a_{t-1}) \quad (2a)$$

$$a^*_t = a(p^*_t, w_t, h_t) \quad (2b)$$

where λ_i is the rate of acreage adjustment; D is a binary variable which is added to determine if the rate of acreage adjustment was different before implementation of the marketing order; a^*_t is the desired (long run equilibrium) level of planted acreage; p^*_t is the expected price in year t; and h_t is a vector of other exogenous factors.

Although a^*_t is unobserved, it may be eliminated by substitution of (2b) into (2a) to yield the short run acreage function

$$a_t = (\lambda_0+\lambda_1 D)a(p^*_t, w_t, h_t) + (1-\lambda_0-\lambda_1 D)a_{t-1}. \quad (3)$$

Once acreage is determine by growers, input levels are chosen conditional on the level of planted acreage. This optimization is embodied in the cost function $c(w_t, y_t)*a_t$. The conditional input demand equations may be obtained by application of Shephard's Lemma (1953) to yield

$$x_{it} = \partial c(w_{it}, y_t)*a_t / \partial w_{it} \qquad i = 1,\ldots,n \quad (4)$$

where x_{it} denotes the quantity of the i^{th} input.

Since planted acreage is fixed at the time of marketing, all variations in output are due to variations in yield (y_t). Thus the relevant equilibrium condition which is based on the hypothesized pricing behavior of the industry is given by

$$p_t*(1 - \xi) = \partial c_t/\partial y_t \tag{5}$$

where ξ is the inverse price elasticity of demand defined as

$$\xi = -(\partial p_t/\partial q_t)*(q_t/p_t). \tag{6}$$

The expression in (5) states that the optimal level of output is determined by equating marginal revenue and marginal cost.

Although the celery marketing order allows some control over the quantity marketed, and hence price, through intraseasonal adjustments in y_t, the extent to which this impacts the pricing behavior of the industry is unknown. If the Florida celery industry markets a quantity that approximates a competitive equilibrium, the marginal condition in (5) would be altered to equate marginal cost to price as opposed to marginal revenue. To account for this possibility, the equilibrium condition in (5) can be generalized to

$$p_t*(1 - \theta\xi) = \partial c_t/\partial y_t \tag{7}$$

where θ $(0 \leq \theta \leq 1)$ indexes implied pricing behavior. A test of the equality of θ before and after implementation of the celery marketing order can be used to assess the impact of the marketing order on price determination. Note that $\theta = 1$ corresponds to the equilibrium condition in (5) whereas $\theta = 0$ yields the equilibrium condition that would typify a perfectly competitive market.

The complete theoretical model may be expressed as

$$x_{it} = \partial c(w_{it}, y_t)*a_t/\partial w_{it} \qquad i = 1,\ldots,n \tag{8a}$$

$$q_t = q(p_t, z_t) \tag{8b}$$

$$p_t*(1 - \theta\xi) = \partial c(w_{it}, y_t)*a_t/\partial y_t \tag{8c}$$

$$a_t = (\lambda_0+\lambda_1 D)*a(p^*_t, w_t, h_t) + (1-\lambda_0-\lambda_1 D)*a_{t-1}. \tag{8d}$$

Equations (8a) and (8b) define the input demand and market demand curves for the industry. Equation (8c) captures the determination of the optimal level of output and Equation (8d) captures the planting decision. Note that although the planting decision is endogenous to the model, it is exogenous to the determination of the final level of price and output.

3. Empirical Model

Empirical estimation of the model described by equations (8a)-(8d) requires specification of an aggregate industry cost function, a market demand function, and a planted acres equation. Labor (x_{lt}), capital (x_{kt}), and intermediate materials (x_{mt}), with respective input prices w_{lt}, w_{kt} and w_{mt}, are taken to be the relevant variable inputs in the industry cost function. Total Florida celery output (q_{ft}) is defined as the product of yield per acre (y_{ft}) and planted acreage (a_{ft}).

The parametric form of the aggregate cost function is given by the quasi-homothetic form of the Generalized Leontief (Diewert 1971) function

$$c = [\sum_i \sum_j a_{ij}(w_{it}w_{jt})^{1/2}]q_{ft} + \sum_i c_{it}w_{it} \qquad i,j = l,k,m \tag{9}$$

where $a_{ij} = a_{ji}$ and $q_{ft} = a_{ft}*y_{ft}$. Quasi-homotheticity embodies the least restrictive assumption that can be maintained on the underlying production technologies of individual firms to establish the existence of an aggregate cost function. In contrast to the usual assumption of homotheticity where all firms have identical and linear expansion paths emanating from the origin, quasi-homotheticity maintains the assumption that the expansion paths of individual firms are linear and parallel, but allows them to differ across firms. Since this means all firms have equal marginal costs, aggregation across firms is possible.

The aggregate industry input demand functions for labor (x_{lt}), capital (x_{kt}), and intermediate materials (x_{mt}) are obtained by the application of Shephard's Lemma (1953)

$$x_{it} = [a_{ii} + \sum_j a_{ij}(w_{jt}/w_{it})^{1/2}]q_{ft} + c_i + b_i x_{i,t-1} \qquad i = l,k,m. \quad (10)$$

The lagged dependent variable in the input demand equation (10) is included to allow for sluggish adjustment to equilibrium levels. As noted by Lau (1978), this is tantamount to assuming the adjustment paths of inputs to be characterized by independent partial adjustment processes.

Since the analysis is conducted at the grower level, the relevant industry demand function is wholesale (shipping point) demand for Florida celery. The parametric form of the demand function is specified to be

$$\ln(q_{ft}) = b + b_f \ln(p_{ft}/e_t) + b_c \ln(p_{ct}/e_t) + b_d \ln(p_{dt}/e_t) \quad (11)$$

where q_{ft} is the wholesale demand for Florida celery measured as total Florida celery production; p_{ft} and p_{ct} are the FOB price of Florida and California celery, the main competitor for Florida; p_{dt} represents the price of diesel fuel which is a proxy measure for the cost of transporting celery to wholesalers; and e_t is total wholesale expenditures on Florida and California celery.

The desired acreage (a^*_t) equation is specified as

$$\begin{aligned} a^*_t = c^* &+ c_f^*(p_f/e)_{t-1} + c_r^*(r_f/e)_{t-1} \\ &+ c_c^* q_{c,t-1} + c_{kl}^*(w_k/w_l)_{t-1} \\ &+ c_{ml}^*(w_m/w_l)_{t-1} \end{aligned} \quad (12)$$

where $p_{f,t-1}$ is the FOB price of Florida celery from the previous year; $r_{f,t-1}$ is Florida's land rent in the past year; $q_{c,t-1}$ is California celery production in the past year; w_k is the capital input price in the past year; w_l is the labor input price in the past year; and w_m is the intermediate materials price in the past year. The unobserved value for desired planted acreage may be eliminated by substituting equation (12) into (2a) and rearranging to obtain

$$
\begin{aligned}
a_t = c &+ c_D{*}D + c_f(p_f/e)_{t-1} + c_{fD}(p_f/e)_{t-1}{*}D \\
&+ c_r(r_f/e)_{t-1} + c_{rD}(r_f/e)_{t-1}{*}D \\
&+ c_c q_{c,t-1} + c_{cD}(q_{c,t-1}){*}D \\
&+ c_{kl}(w_k/w_l)_{t-1} + c_{klD}(w_k/w_l)_{t-1}{*}D \\
&+ c_{ml}(w_m/w_l)_{t-1} + c_{mlD}(w_m/w_l)_{t-1}{*}D \\
&+ c_\lambda a_{t-1} - c_{\lambda D}(a_{t-1}){*}D
\end{aligned} \qquad (13)
$$

where $c = \lambda_0 c^*$; $c_D = \lambda_1 c_D^*$; $c_f = \lambda_0 c_f^*$; $c_{fD} = \lambda_1 c_{fD}^*$; $c_r = \lambda_0 c_r^*$; $c_{rD} = \lambda_1 c_{rD}^*$; $c_c = \lambda_0 c_c^*$; $c_{cD} = \lambda_1 c_{cD}^*$; $c_{kl} = \lambda_0 c_{kl}^*$; $c_{klD} = \lambda_1 c_{klD}^*$; $c_{ml} = \lambda_0 c_{ml}^*$; $c_{mlD} = \lambda_1 c_{mlD}^*$; $c_\lambda = 1-\lambda_0$; $c_{\lambda D} = \lambda_1$. D is a binary variable whose value is zero for the period 1961-1982 (i.e., the marketing order era) and is one for the period 1950-1960 (i.e., the pre-marketing order era).

Given the aggregate optimality condition for the industry (7), the aggregate cost function (9), the aggregate input demand functions (10), the wholesale demand (11), and the specifications for the Florida acreage equation (13), the complete system estimated with cross price symmetry imposed is

$$
\begin{aligned}
x_{lt} &= [a_{ll} + a_{lk}(w_{kt}/w_{lt})^{1/2} + a_{lm}(w_{mt}/w_{lt})^{1/2}]q_{ft} + c_l + b_l x_{l,t-1} \\
x_{kt} &= [a_{kk} + a_{lk}(w_{lt}/w_{kt})^{1/2} + a_{km}(w_{mt}/w_{kt})^{1/2}]q_{ft} + c_k + b_k x_{k,t-1} \\
x_{mt} &= [a_{mm} + a_{lm}(w_{lt}/w_{mt})^{1/2} + a_{km}(w_{kt}/w_{mt})^{1/2}]q_{ft} + c_m + b_m x_{m,t-1}
\end{aligned}
$$

$$\ln(q_{ft}) = b + b_f \ln(p_{ft}/e_t) + b_c \ln(p_{ct}/e_t) + b_d \ln(p_{dt}/e_t)$$

$$p_{ft} = [a_{11}w_{1t} + a_{kk}w_{kt} + a_{mm}w_m + 2a_{1k}(w_{1t}w_{kt})^{1/2} + 2a_{1m}(w_{1t}w_{mt})^{1/2} + 2a_{km}(w_{kt}w_{mt})^{1/2}]/(1 + \theta/b_f) \tag{14}$$

$$a_{ft} = c + c_D{*}D + c_f(p_f/e)_{t-1} + c_{fD}(p_f/e)_{t-1}{*}D + c_r(r_f/e)_{t-1} + c_{rD}(r_f/e)_{t-1}{*}D + c_c q_{c,t-1} + c_{cD}(q_{c,t-1}){*}D + c_{k1}(w_k/w_1)_{t-1} + c_{k1D}(w_k/w_1)_{t-1}{*}D + c_{m1}(w_m/w_1)_{t-1} + c_{m1D}(w_m/w_1)_{t-1}{*}D + c_\lambda a_{t-1} - c_{\lambda D}(a_{t-1}){*}D$$

$$q_{ft} = y_{ft}{*}a_{ft}.$$

To determine if the price determination is different before and after the marketing order, θ in the above equation system is replaced by the linear function

$$\theta = g + g_d D \tag{15}$$

where D is a binary variable whose value is zero for the period 1961-1982 and is one for the period 1950-1960. The hypothesis that the marketing order did not change the pricing behavior of the Florida celery industry is statistically investigated by testing the null hypothesis $g_d = 0$.

The data used for estimation spanned the 1950 to 1982 period and include 33 observations. A discussion of the data is not included because of lack of space. To reflect errors in optimizing behavior, disturbance terms were appended to the individual equations in (14). The disturbance vectors of the individual equations are assumed to be joint normally distributed with mean zero and non-singular covariance matrix, Ω, satisfying

$$E\,[u_i(t)u_j(s)'] = \Omega \text{ if } t = s; \quad = 0 \text{ if } t \neq s \tag{16}$$

where u_i denotes the disturbance vector of the ith equation. Estimation of the system was accomplished using non-linear three stage least squares.

4. Results

Table 1 contains parameter estimates and corresponding asymptotic standard errors. Of the 32 parameters estimated, 16 (50 percent) have values that exceed two times their respective asymptotic standard errors. Furthermore, using the testing procedure suggested by Gallant-Jorgenson (1979), the hypothesis that $\lambda_1=0$ yields a test statistic of $T^0=31.93$. The critical value of the Chi square distribution at the .001 level of significance with seven degrees of freedom is 24.32. Thus, the hypothesis that $\lambda_1=0$ is rejected. λ_1 is different from zero even though its asymptotic standard error is large (Table 1). The large standard error is likely due to multicollinearity caused by the addition of the binary variables to the acreage equation. The estimated cost function satisfies symmetry, homogeneity of degree one in input prices, monotonicity, and concavity (at the mean values of the data).

The hypothesis that the pricing behavior of the Florida celery industry does not statistically depart from the marginal cost pricing rule that would typify a perfectly competitive market is rejected (θ as represented by $g = 0.224$). However, the hypothesis that the price determination before and after the marketing order is the same could not be rejected as the estimated value of g_D was not significantly different from zero.

In contrast to the implied pricing decisions, the planted acres equation reveals several differences before and after implementation of the marketing order. The hypothesis $c_{fD}=0$ implies that expected price influenced planted acreage in an equivalent manner before and after the implementation of the marketing order. This hypothesis is rejected (c_{fD} = .993). Without the marketing order to set production, farmers apparently followed a Cobweb model in making acreage adjustments from one year to the next. Lagged Florida price influenced the current acreage planted. After the marketing order was in operation, lagged Florida price was not a factor influencing planted acreage (c_f was not significantly different from zero).

Lagged planted acreage is more important in determining the current acreage with the marketing order than prior to its implementation. Before the marketing order, the parameter of the binary variable associated with Florida's lagged acreage planted ($c_{\lambda D}=\lambda_1=.265$) was significantly different from the parameter with the marketing order ($c_\lambda=1-\lambda_0=.499$) (see the Gallant-Jorgenson T^0 statistic previously discussed). $c_\lambda - c_{\lambda\Delta}$ (i.e. $1-\lambda_0-\lambda_1$) gives the actual impact of the previous years acreage on the current years acreage without the marketing order (.234). With the marketing order, the parameter was .499 and significant.

Furthermore, $c_{\lambda D}=\lambda_1=0$ tests the hypothesis that the rate of adjustment (λ_0) of actual acreage to the desired acreage (equation 2a) did not change with the implementation of the marketing order. The hypothesis is rejected ($c_{\lambda D}=\lambda_1=.265$). Celery acreage from one year to another exhibits more stability after the implementation of the marketing order. The fraction of desired change allowed in the current seasons acreage (Equation 2a) before ($\lambda_0+\lambda_1$) and after (λ_0) implementation of the marketing order was .766 and .501, respectively. Without the marketing order, Florida celery farmers adjusted acreage more rapidly to market conditions. With the marketing order, the celery industry was more cognizant of the constraints imposed by the specialized capital stock currently owned and the need to service clients.

The hypothesis $c_{cD} = 0$ implies that lagged California production exhibits no change in importance in determining the current acres planted before or after the marketing order. This hypothesis cannot be rejected. California has always been an important factor in the decision to adjust acreage for the next season (c_c=-.358). It is not surprising that the marketing order takes California's previous years production into account when deciding how many acres to plant. California production has been shown to influence Florida demand (Shonkwiler and Pagoulatos 1980, p. 117). California produced 72.7 percent of the celery in the United States in 1982 while Florida produced 16.2 percent (U.S. Department of Agriculture, Agricultural Statistics). California is not a member of the marketing order but is Florida's primary competitor.

5. Summary and Conclusions

The purpose of this analysis was to assess the economic behavior of the planted acreage decisions in the Florida celery industry before and after the installment of the State and Federal marketing orders. The implied pricing behavior before and after the marketing order is not shown to be statistically different but is shown to deviate from a price equals marginal cost pricing decision rule.

Prior to the marketing order, the industry placed emphasis on lagged Florida price, lagged California quantity and lagged Florida acreage to determine the current acreage planted. After implementation of the marketing order, lagged Florida price was not a consideration. However, the importance of lagged acreage increased considerably after the marketing order was implemented. The importance of lagged California production was the same before and after the marketing order. Finally, the fraction of desired change allowed in the current seasons acreage (λ_i in Equation 2a) before and after implementation of the marketing order was .766 and .501. This indicates more stability from year to year in acres planted after the marketing order was implemented than before implementation.

Table 1. **Parameter estimates.**

Parameter	Estimate	Standard Error[a]
a_{11}	-.150	.127
a_{1k}	.603	.173
a_{1m}	-.273	.103
c_1	-.042	.105
b_1	.829	.028
a_{kk}	-1.751	.411
a_{mk}	.744	.226
c_k	.786	.142
b_k	.592	.120
a_{mm}	.094	.141
c_m	-.229	.142
b_m	.625	.127
b	-.526	.151
b_f	-.407	.132
b_c	-.154	.085
b_d	-.212	.042
c	1.007	.450
c_D	-.161	.708
c_f	.178	.303
c_{fD}	.993	.439
c_λ	.499	.194
$c_{\lambda D}$	.265	.261
c_r	.032	.083
c_{rD}	-.228	.226
c_c	-.358	.110
c_{cD}	.047	.178
c_{k1}	-.165	.153
c_{k1D}	-.013	.259
c_{m1}	-.009	.089
c_{m1D}	.067	.125
g	.224	.090
g_D	-.033	.023

[a]Asymptotic standard errors.

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