The Potential for Supply Management Of Southeastern Sweet Onions

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The degree of effectiveness of a marketing order limiting shipments was examined by simulating prices, shipments, and total revenue. The results suggest that a supply management marketing order would be beneficial to Southeastern sweet onion producers. These findings reinforce the importance of a marketing plan for achieving price and revenue goals over the course of a shipping season. Optimal control appears appropriate as a tool to determine intraseasonal shipment goals for a number of commodities under the umbrella of a marketing order.

Introduction

A marketing order is one of several marketing policy tools used in U.S. agriculture. It is a program that integrates industry with government and may facilitate the regulation of quantity and/or quality of specified commodities entering the market channel (Knutson et al., 1986).

Three broad categories of activities encompassing quality control, market support, and quantity control are undertaken via federal marketing orders for fruits and vegetables (Jesse and Johnson, Jr., 1981; Jesse, 1982; U.S.. Department of Agriculture, 1981; U.S. General Accounting Office, 1985; Zepp and Powers, 1988). Quality control is implemented through shipping restrictions on certain sizes and grades. The rationale is to remove off-grade commodities so as to command a higher price for higher quality commodities and to reduce available sales to yield indirect effects on quantity supplied (Price, 1967). Market support activities include shipping container and pack standards as well as research and promotion in order to contribute to marketing efficiency. Quantity control provisions consist of volume management of total seasonal sales and market flow regulations in the intraseasonal distribution of sales. Both quality control and market support activities contribute to the indirect change of supply (Knutson et al., 1986; U.S. Department of Agriculture, 1981; Jesse, 1979).

The biological nature of the agricultural production process requires that farm output reflect an adjustment period which is partly dependent upon uncertain events (Tomek and Robinson, 1981). Although modeling the impact of marketing orders is particularly difficult because of the time dimensions involved, failure to consider the dynamic adjustment path may lead to biased estimates of economic welfare (Berck and Perloff, 1985).

The intent of this study was to evaluate the potential of a marketing order which facilitates the regulation of intraseasonal market flows directly or indirectly for sweet onions produced in the Southeastern United States. Sweet onions were singled out for study because of the attention received in the establishment of a Federal marketing order (Federal Register, 1989 and 1990). A marketing order was established for sweet onions grown in southeastern Georgia. The initial order restricts use of the name "Vidalia Onions" to onions produced within the specified territory and provides for a check-off mechanism to support advertising and research.

The study was carried out in two steps. First, the controlled intraseasonal weekly shipping pattern that maximized total revenue collectively for Southeastern sweet onion producers and the actual intraseasonal shipping pattern were ascertained. Second, the effectiveness of the controlled shipping pattern was measured relative to the actual case in terms of shipments, prices, and total revenue.

The paper is organized as follows. An optimal control model is presented first. Next, a dynamic econometric model used in the analysis is depicted. Empirical results follow for the two market scenarios--

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the actual case and the marketing order case. Conclusions and suggestions for implementation follow.

The Control Model

Commodity market problems are characterized by uncertainty in climate and supply-demand conditions and by lagged reactions to price and quantity changes (Pindyck, 1973; Just, 1975; Newberry and Stiglitz, 1981). These attributes of uncertainty and dynamics point to stochastic control theory as a useful tool for analyzing problems involving the determination of optimal weekly shipments. The linear/quadratic formulation has been widely used to solve a variety of optimal control problems (Dixon and Howitt, 1980).

In order to solve the optimization problem, an objective or loss function and an appropriately specified econometric model, which is employed as the constraint set, is required. The linear reduced-form equations for the econometric model, the loss function, and the solution procedure for the control framework are presented in the Appendix. The empirical setup and solution procedure to determine optimal weekly shipments of Southeastern sweet onions in an optimal control framework are presented in the next section.

Empirical Formulation, Estimation, and Solution

The goal of the optimal control model was to choose a sequence of actions that would achieve the desired result (maximize total revenue) subject to the reduced-form econometric model. The sequence of actions, x_t, for this study was the shipment of weekly quantities, where such shipments represent the control variable. The optimal control procedure required minimization of a loss function in order to achieve the desired result. Specifically, this involved minimization of the squared differences between target shipment quantities and prices, a_t, and predicted shipment quantities and prices, Y_t (appendix equations 1-3). Target values, a_t, were the prices and quantities of Southeastern sweet onions that yielded unitary own-price flexibilities of demand. Such an approach for maximizing total revenue was similar to that used by Carman and Pick (1990). The weighting matrix, K_t, was an identity matrix for this analysis as there was insufficient reason to weight the loss function asymmetrically (appendix equation 3). Thus, the answers produced by the control model were a result of the supply and demand model and the general form of the loss function and not the result of being forced onto some desired path by the weighting matrix.

Estimation of the Southeastern supply and demand model was based on weekly shipments and prices for sweet onions from early-April to mid-June for 1982 through 1988. Variables used in the empirical estimation are described in Table 1.

The number of weeks for the sweet onion season is about 10 weeks. The starting shipping week of the season in each year was identified as the first week in that time series. The data series for sweet onions encompassed 50 observations. Weekly shipment and f.o.b. price data were obtained from U.S. Department of Agriculture, Agricultural Marketing Service (1982-1988). Price data were deflated by the consumer price index (CPI) (1982-84 = 100). The index was obtained from U.S. Department of Labor, Monthly Labor Review (1982-1988).

Table 1
Definition of Variables for the Empirical Model

Variable	Description
SQ_t	Shipments of sweet onions from the Southeastern U.S. in week t (100 cwt.)
SP_t	Real f.o.b. price of sweet onions for the Southeastern U.S. in week t ($/100 cwt.)
UQ_t	Imputed total U.S. production of sweet onions in week t (100 cwt.)[a]
QT_t	Imputed production of sweet onions in competing regions in week t (100 cwt.)[a]
SRI_t	Real Southeastern per capita income in week t ($)
PYO_t	Real f.o.b. price of pungent yellow onions in week t ($/100 cwt.)

[a]Imputed values are explained in the text.

Weekly production for the United States and regions outside of the Southeast (competing regions) was imputed by transforming weekly shipment data into weekly production data via the annual shipment-to-production ratio. Shipment data which are reported by the U.S. Department of Agriculture, Agricultural Marketing Service do not account for total production, and weekly production data are not available (U.S. Department of Agriculture, 1983-1989). Per capita income data were obtained from U.S. Department of Commerce, Survey of Current Business (1982-1988), which were deflated by the CPI. Real per capita income in the t^{th} week of year r corresponds to reported monthly per capita income.

Dynamic adjustment was introduced through the assumption that shipments cannot change immediately in response to new economic conditions. Thus, the actual change in shipments in week t is a fraction of the planned change in shipments. Similarly, price changes were also assumed to reflect the partial adjustment process.

The supply and demand model was estimated encompassing an inverse demand equation which is similar in approach to a number of studies: for example, Carman and Pick (1990), Leuthold and Hartmann (1979), Davis and Hise (1979), O'Rourke and Masud (1980), Shonkwiler and Emerson (1982), Eckstein (1985), Seale and Shonkwiler (1987), and Garcia et al. (1988). The inverse demand formulation is consistent with the control framework employed in this study.

The structural model depicted in Table 2 was estimated for the sole purpose of obtaining weekly price flexibilities in order to select weekly shipment targets for the optimal control model. All of the coefficients in the model have the expected signs. The coefficients for the dynamic (lagged) variables are significant at the 0.01 level or better. Lag length was limited to one week because of the highly perishable nature of sweet onions. Given the short time frame for supply response, activities in one week have a strong relationship to activities in the subsequent week. In other words, supply and demand can shift from week to week within limits dictated by the coefficients of lagged and other exogenous variables.

Shipments (SQ_t), which do not account for production, and f.o.b. prices (SP_t) were used in the model since the market information system of the Agricultural Marketing Service provides this information through various forms on a continuous basis. Imputed U.S. production (UQ_t) was included in the supply equation as an indicator of the overall crop condition. Imputed production in competing regions (QT_t) was included as an indicator of Southeastern shipping opportunities. Southeastern per capita income (SRI_t) was used in the model because a large share of the sweet onions was expected to be consumed in the Southeast. The f.o.b. price of pungent yellow onions (PYO_t) was included to reflect a possible substitution effect. Given the short duration of the decision intervals (weekly) in the model, per capita income (SRI_t) does not seem to be important. Similarly, week-to-week substitution with pungent yellow onions does not seem important.

Table 2

Two-Stage Least Squares Coefficient Estimates
and Asymptotic t-Values ( )
for Southeastern Sweet Onions

Variable	Supply (SQ_t)	Demand (SP_t)
Constant	-242.2178	-1919.3866
	(-1.3527)	(-1.7125)
SQ_t		-3.4259
		(-1.9794)
SQ_{t-1}	0.8174	
		(2.8674)
SP_t	0.1394	
		(1.0529)
SP_{t-1}		0.9132
		(3.5219)
UQ_t	0.1312	
	(1.9211)	
QT_t	-0.1129	
	(-1.8798)	
SRI_t		1.2034
		(0.8935)
PYO_t		0.2019
		(0.0466)
$\hat{\rho}^a$	0.1509	-0.1859

Note: The supply equation is a quantity-dependent specification, while the demand equation is a price-dependent specification. The variables are defined in Table 1.

[a] $\hat{\rho}$ is the sample correlation coefficient, $\hat{\rho} = \frac{\sum_{t=2}^{T} \hat{e}_t \hat{e}_{t-1}}{\sum_{t=1}^{T} \hat{e}_t^2}$, where $\hat{e}_t$ are residuals (Judge et al., 1985, p. 286).

Computed price flexibilities at mean values of weekly demand based on coefficients from Table 2 range from -0.01 to -0.81, generally decreasing over the season for the Southeast. These flexibilities indicate that prices are not very responsive to changes in shipments for a given week. This is indicative of partial adjustment from week to week.

Computed own-price elasticities for Southeastern sweet onions at mean values of weekly supply are 33.66 for the first week and 3.84 for the second week, reflecting high prices and low shipment volume. For the remaining eight weeks, own-price elasticities of supply generally decline from 1.25 to 0.59, reflecting the weekly partial adjustment process in that shipments do not appear to be very responsive to price changes.

Regarding the dynamic stability of the supply and demand system, the system is stable as the eigenvalues of the fundamental dynamic equations are positive and less than one. An explanation for deriving fundamental dynamic equations can be found in Kmenta (1986), pp. 724-726.

Results and Implications

The results of the study are summarized in Table 3. Shipments and corresponding prices by week of the season are provided for the two market scenarios examined--the actual case versus the marketing order case. In addition, total revenue for the season is shown for each of the market cases. The values for the marketing order case in Table 3 were obtained via solution of the optimal control problem as previously described.

Comparison of the values for the actual case and the marketing order case reveal substantial differences. Shipments were generally lower and prices and total revenue much higher for the marketing order case. The direction that these values varied one from the other with respect to the two cases examined was expected. However, the magnitude of the differences is quite telling regarding the potential gains to producers of Southeastern sweet onions via a marketing order.

For the first two weeks of the season, actual shipments were less than those for the marketing order case. As production begins, it is difficult or impossible to ship large volumes immediately. Given these limited supplies at the onset of the harvest season, one would expect higher prices in light of the results shown for the marketing order case. The relatively low actual prices in the first two weeks of the season reflect quality attributes, especially shipments of small onions.

Table 3

Actual Average and Marketing Order Shipments and F.O.B. Prices for Southeastern Sweet Onions by Week of the Season and Total Revenue

	Actual Average		Marketing Order	
Week	Shipments (SQ)	FOB Price (SP)	Shipments (SQ)	FOB Price (SP)
	(100 cwt)	*($/100 cwt)*	*(100 cwt)*	*($/100 cwt)*
1	14.0	3,380	218.5	4,780
2	124.2	3,424	223.3	4,785
3	361.0	3,230	220.2	4,796
4	400.0	2,821	223.6	4,793
5	299.1	2,516	219.7	4,802
6	288.9	2,070	222.7	4,798
7	305.7	1,693	217.5	4,810
8	281.4	1,448	218.7	4,812
9	314.7	1,306	209.4	4,836
10	307.6	1,303	194.3	4,859
Total revenue[a]	5.9[a]		10.4[a]	

[a]10^6 dollars.

As shown in Table 3, actual average prices generally declined over the course of the marketing season. These actual prices were associated with shipment volumes substantially larger than those shown for the marketing order case. Moreover, high volume shipments in the latter part of the season are associated with quality deterioration, especially in terms of size.

At the beginning of the harvest season, the size of the onions and volume of shipments have tended to be insufficient. Improvements may possibly be made at the beginning of the harvest season, but not to any large extent due to biological constraints.

Difficulty towards the end of the harvest season is another matter. Nonshipment of onions of insufficient quality, which is quite feasible, should greatly enhance revenue to producers.

The market order solution encompassing lower shipment quantities and higher prices over most of the season, Table 3, reflects the impact of sweet onion supplies from competing regions through the supply equation in Table 2. Over time, the impact of sweet onion supplies from competing regions may change if the degree of product differentiation for sweet onions changes by region of origin.

The market order solution represents a plan for producers to follow, to the extent possible, for higher revenues. Following the plan will clearly affect the quality of the product in a very positive way. In fact, quality standards can be used to bring shipment quantities in line with the market order solution.

This should spur increased competition on the basis of quality for the entire sweet onion industry, perhaps, leading to an increase in consumer demand. Such a turn of events, of course, would allow an increase in the supply of quality sweet onions to the benefit of producers and consumers alike.

Conclusions and Implementation

The degree of effectiveness of a marketing order involving shipment limits was examined through a comparison of price, shipment, and total revenue measures with those of the actual case. The results of the study suggest that supply management would be beneficial to Southeastern sweet onion producers. Thus, an orderly marketing plan can be useful in achieving price and revenue goals throughout the shipping season.

The results of the analysis are encouraging regarding the usefulness of control methods in ascertaining an optimal trajectory or pattern of shipments involving dynamic adjustment over the course of the harvesting and marketing season for Southeastern sweet onions. The approach appears appropriate as a market strategy tool for similar commodities under similar circumstances. Model specification, of course, would need to be altered with respect to other commodities.

The empirical application depicted in this paper reflects near perfect information at least to the extent that the data are accurate. The results, then, reflect possibly an upper limit on returns to supply management. In actual practice, all of the relevant information needed for ideal supply-management decisions would not be so complete. Faced with this reality, projected values for the variables in the model are needed for the current shipping season, depending on the stage of the season. Just prior to the beginning of the season, projections are needed for each week of the season and must be added to the historical data set in order to obtain a current solution from the optimal control model. As the season progresses, projected values may be replaced by actual values as new information is made available, allowing updated solutions from the control model. At any time there is new information, whether actual or projected, the control model can be used to obtain a new solution for weekly shipments.

The most effective and timely way to obtain projections for important variables will depend, of course, on the nature of the variables of interest. In the case of onions, projections for shipments and production can be made from acreage and production forecasts published by the National Agricultural Statistics Service. Forecasts for Southeastern sweet onions were initiated in 1990. Prices can be projected based on projected shipments and previous demand relationships. Changes in per capita income are small over short periods of time and present little difficulty in making projections.

A single solution for a current season of shipments is inadequate in actual practice. For the most effective use of the optional control model, a number of solutions are needed for a given season. The model should be used to solve for the desired shipping pattern each time new information and/or new projections are obtained.

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Appendix

The linear reduced form model may be expressed as:

(1) $$y_t = A_1 Y_{t-1} + \dots + A_m y_{t-m} + c_0 x_t + \dots + c_n x_{t-n} + B w_t + u_t$$

where $A_1, \dots, A_m$, $C_0 \dots, C_n$, and B are random parameters with respect to a joint density function, y_t is a vector of endogenous variables, x_t is a vector of control variables or instruments, w_t is a vector of exogenous variables not subject to control, and u_t is a random error vector normally distributed with mean 0 and covariance matrix $\tilde{\Sigma}$. The values of u_t are assumed to be serially uncorrelated and uncorrelated with random parameters $A_1, \dots, C_n$, and B. In matrix notation,

(2) $$Y_t = AY_{t-1} + Cx_t + b_t + \tilde{U}_t$$

where

$$b_t = Bw_t,$$
$$E\tilde{U}_t = 0,$$
$$E\tilde{U}_t\tilde{U}_t' = \psi, \text{ and}$$
$$E\tilde{U}_t\tilde{U}_v' = 0 \text{ for } t \neq v.$$

The quadratic loss function to be minimized is

(3) $$W = E_{t-1}\sum_{t=1}^{T}(Y_t - a_t)'K_t(Y_t - a_t) = E_{t-1}\sum_{t=1}^{T}(Y_t'K_tY_t - 2Y_t'K_ta_t + c_t),$$

where T is the length of the planning horizon, a_t represent the target values of Y_t, K_t is a weighting matrix which is usually diagonal and positive semi-definite, $c_t = a_t'K_ta_t$, and E_{t-1} represents expectations conditional on all the information available through the end of period t-1 (Chow, 1975).

The optimal control problem is to choose x_1, x_2, ..., x_T so as to minimize the expected loss (3) given the econometric model (2) and initial equations which Chow (1975) derived for the dynamic programming solution are

(4) $$\hat{x}_t = \hat{G}_tY_{t-1} + \hat{g}_t \qquad t = 1, \dots, T,$$

with feedback matrix $\hat{G}_t$ and forcing vector $\hat{g}_t$ given by

(5a) $$\hat{G}_t = -(E_{t-1}C'H_tC)^{-1}(E_{t-1}C'H_tA) \qquad t = 1,2,\dots,T,$$

(5b) $$\hat{g}_t = -(E_{t-1}C'H_tC)^{-1}[(E_{t-1}C'H_tb_t) - (E_{t-1}C')h_t] \qquad t = 1,2,\dots,T,$$

and matrix/vector Ricatti equations

(6a) $$H_{t-1} = K_{t-1} + E_{t-1}(A'H_tA) + \hat{G}_t'(E_{t-1}C'H_tA) \qquad t = 2,3,\dots,T,$$

(6a′) $$H_t = K_t \qquad t = T,$$

(6b) $$h_{t-1} = K_{t-1}a_{t-1} + E_{t-1}(A + C\hat{G}_t)'(h_t - H_tb_t) \qquad t = 2,3,\dots,T,$$

and

(6b′) $$h_t = K_ta_t \qquad t = T.$$

The $(\hat{G}_t, \hat{g}_t)$ and (H_t, h_t) pairs are computed alternatively and recursively from t = T to t = 1 by (5) and (6). The optimal policies and states are then computed from t = 1 to t = T by (4).

The optimal sequences shown above reflect passive learning. The linear/quadratic control procedure as described anticipates that learning will occur through reestimation of the unknown parameters of the linear model as additional observations are obtained with the passage of time (Chow, 1975, pp. 257-276).