A Bargaining Model of Price Discovery in the Washington/Oregon Asparagus Industry

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ABSTRACT

The bargaining process and its role in price discovery within the U.S. asparagus industry is modeled. The growers and processors inverse supply and demand functions define boundaries for the negotiated processed asparagus prices. OLS and Heckman's two-stage estimation procedures are used to estimate the bargaining model, and implications of the results are discussed.

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Introduction

Asparagus is sold by growers for either fresh or processed uses. The price of fresh asparagus is determined by supply and demand forces. The price discovery for most processing asparagus in the United States is through negotiation between growers' bargaining associations and processors. The bargaining process occurs prior to harvest each year to establish the price and expected volume of processing asparagus for the coming season.

The characteristics of the bargaining process suggest that the processed asparagus market operates within a monopoly/monopsony-like context. The typical price equilibrium where supply equals demand breaks down under such behavior, as is well-known. In particular, the price equilibrium under bargaining not only depends upon supply and demand forces, but also on the relative bargaining power of the sellers and buyers.

In the case of the Washington/Oregon asparagus industry, negotiations establish both the price and the expected volume of processing asparagus for the upcoming season. At the beginning of each year the grower's bargaining association announces an opening price offer based on the growers' perceptions of asparagus market conditions. Processors give their response within three days following the announcement. The opening price becomes the final price for processing asparagus if the majority of processors agree to accept it. If not, the growers' bargaining association makes a second price offer within five days. The second price offer may or may not be the same as the first. If the second offer is accepted, it becomes the price for processing asparagus in the coming season. If not, the price of processing asparagus is determined by an arbitration board. The arbitration board is composed of representatives of the growers and processors and other members who are appointed by the states' Departments of Agriculture. In practice, either the first or second price offer has always become the final price of processing asparagus. There have been only two years in which the final price of processing asparagus was determined by the arbitration board during the past 30 years, and in both cases, the second price offer of the growers was adopted by the board.

A number of models of the asparagus industry have been analyzed in the last two decades. In 1972, French and Matthews formulated a model of the U.S. asparagus industry. Grossman (1973) developed a structural model of the asparagus industry at the regional level. Hoos and Runsten (1977) constructed a linear and logarithmic multiple regression model to predict the grower price for processing asparagus in California. In the 1980s, an econometrics model for the U.S. asparagus industry was developed by Bbuyemusoke, et. al. Another econometric model of the U.S. asparagus industry was developed by French and Willett (1989). However, none of these past models contained an explicit bargaining component.

The objective of this paper is to identify the primary factors that affect price offers, and ultimately the final price of processed asparagus in the Washington/Oregon asparagus industry. To accomplish this objective, an econometric model of the bargaining process that leads to price offers, and ultimately a final negotiated price, is constructed.

Theoretical Model of the Bargaining Process

Various market equilibrium and disequilibrium situations are possible within the bargaining context. A standard market equilibrium model can be conceptualized as containing four essential equations, consisting of a demand equation, a supply equation, a price equilibrium equation, and a quantity equilibrium equation (Table 1, entry 1). Given the demand and supply equations, if either or both of the price and quantity equilibrium conditions are violated, market disequilibrium results. Bargaining can lead to a solution under market disequilibrium, which can be classified into three types: 1) price bargaining; 2) quantity bargaining; and 3) bargaining for both price and quantity (see Table 1, entries 2, 3, and 4). This study deals with price bargaining for a given quantity to be traded, which is the case for processed asparagus as described above (Table 1, entry 3).

The expected quantity of processing asparagus to be traded is agreed upon before pricing is established in the processed asparagus industry. If neither side of the market is a price taker, or both parties have some market or bargaining power to influence the price, then the seller cannot set a price on the demand curve and the buyer cannot set a price along the supply curve.

There are two features of price determination under bargaining that distinguish it from the typical market equilibrium analysis. First, the equilibrium price under bargaining cannot be uniquely determined by supply and demand equations alone because the bargaining activities play a role in price determination. Second, the estimation of the demand and supply equations will be biased and inconsistent due to actual price observations not being located on both the demand and supply curves.

The supply and demand curves can be considered as the lower and the upper price boundaries for the price bargaining process, respectively. The equilibrium price under bargaining for a given quantity to be traded can be expressed as a convex combination of the inverse supply and demand functions characterized by a parameter of bargaining power, α, which takes a value between 0 and 1. Hence, an economic model of price discovery under bargaining is given by:

(1) $P_d = P_d(Q_d, Z_d)$ Buyer's Inverse Demand

(2) $P_s = P_s(Q_s, Z_s)$ Seller's Inverse Supply

(3) $Q_d = Q_s = Q^*$ Quantity Equilibrium

(4) $P^* = (1-\alpha)P_s + \alpha P_d$ Price Equilibrium under Bargaining

where: Q^* = the agreed quantity to be traded; P^* = the equilibrium price under bargaining; Z_d = inverse demand shifters; Z_s = inverse supply shifters; and α = parameter of relative bargaining power. Some implications of various values of α are as follows:

under monopoly: $\alpha = 1$ $P^* = P_d$

under monopsony:	$\alpha = 0$	$P^* = P_s$
under competition:	indeterminate	$P^* = P_d = P_s$
under bargaining:	$\alpha \,\varepsilon\, (0,1)$	$P_s < P^* < P_d$

Solving this market equilibrium model under bargaining, the final bargained price can be written as:

(5) $P^* = (1\text{-}\alpha)P_s\,(Q, Z_s) + \alpha\, P_d\,(Q, Z_d) = f(Q, \alpha, Z_s, Z_b)$

For purposes of estimation, represent both the sellers' inverse supply function and the buyers' inverse demand functions in stochastic form as follows:

(6) $P_s = P_s\,(Q_s, Z_s) + \varepsilon_s = f_s(X) + \varepsilon_s$ Sellers' inverse supply

(7) $P_d = P_d\,(Q_d, Z_d) + \varepsilon_d = f_d(X) + \varepsilon_d$ Buyers' inverse demand

(8) $E(\varepsilon_s) = E(\varepsilon_d) = 0$ Zero mean of error terms

where ε_s and ε_d are the error terms for the inverse supply and demand functions, respectively. Here X represents a universal set of explanatory variables, affecting supply and demand and we are treating the parameters as being implicit in the representation of these functions and in other functions below. All other variables retain their earlier definitions.

Since sellers will make an opening offer above their supply curve if they are not price-takers, the sellers' opening or first price offer, $P_{s,1}$ can be represented as the inverse supply function plus an increment $\Delta P_{s,1}$ which is related to the sellers' perceptions of market conditions and bargaining strength, as:

$$
\begin{aligned}
(9)\quad P_{s,1} &= [P_s + \Delta P_{s,1}] + \varepsilon_{s,1} \\
&= [f_s(X) + \varepsilon_s] + [\Delta f_{s,1}(X) + \Delta\varepsilon_{s,1}] + \varepsilon_{s,1} \\
&= [f_s(X) + \Delta f_{s,1}\,(X] + [\varepsilon_s + \Delta\varepsilon_{s,1} + \varepsilon_{s,1}] \\
&= f_{s,1}\,(X) + \varepsilon^*_{s,1}
\end{aligned}
$$

or

$$(10)\quad P_{s,1} = f_{s,1}(X) + \varepsilon^*_{s,1},\ \text{with } E[\varepsilon^*_{s,1}] = 0,$$

where $f_{s,1}$ (X) represents the expectation of the sellers' first price offer and $\varepsilon^*_{s,1}$ is the error term having a zero mean.

To make a decision regarding the acceptability of a price offer, buyers must have a threshold price in mind. If the sellers' offer is less than or equal to it, the buyer will accept the price offer. If the offer is higher, the buyers will reject it. The buyers' threshold price, $P_{d,1}$, can be defined as the buyers' inverse demand, P_d, less an increment, $\Delta P_{d,1}$, that is a function of the buyers' perceptions about market conditions and bargaining strength, as:

(11) $$\begin{aligned} P_{d,1} &= [Pd - \Delta P_{d,1}] + \varepsilon_{d,1} \\ &= [f_d(X) + \varepsilon_d] - [\Delta f_{d,1}(X) + \Delta\varepsilon_{d,1}] + \varepsilon_{d,1} \\ &= [f_d(X) - \Delta f_{d,1}(X) + [\varepsilon_d - \Delta\varepsilon_{d,1} + \varepsilon_{d,1}] \\ &= f_{d,1}(X) + \varepsilon^*_{d,1} \end{aligned}$$

or

(12) $P_{d,1} = f_{d,1}(X) + \varepsilon^*_{d,1}$, with $E[\varepsilon^*_{d,1}] = 0$,

where $f_{d,1}$ (X) is the expectation of the buyers' threshold price and $\varepsilon^*_{d,1}$ is the error term having a zero mean.

The difference between the sellers' first price offer and the buyers' threshold price, Y_1^* can be used to characterize the price bargaining outcome at the first stage. The criterion function for the bargaining outcome will be:

(13) $Y_1^* = P_{s,1} - P_{d,1} = [f_{s,1}(X) - f_{d,1}(X)] + [\varepsilon_{s,1} - \varepsilon_{d,1}] = f_1 (X) + \varepsilon_1^*$

or

(14) $Y_1^* = f_1 (X) + \varepsilon_1^*$, with $E(\varepsilon_1^*) = 0$.

If $Y_1^* \leq 0$, which implies $P_{s,1} \leq P_{d,1}$, then the buyers will accept the sellers opening price offer and the bargaining process ends. The final price, P_f^*, will be the sellers' opening price offer, or:

(15) $P^* = P_{s,1} = f_{s,1}(X) + \varepsilon^*_{s,1}$

The criterion variable Y_1^* is unobservable since the buyers' threshold is not made public. However, information about the buyers' decision during the bargaining process is available in terms of the growers' price offers, the buyers' decisions, and the final price. Thus, whether the final price equals $P_{s,1}$ can be represented by using a probit or logit procedure by defining an observed indicator variable Y as:

(16) $Y = 0$ if $Y_1^* \leq 0 \Rightarrow$ the offer $P_{s,1}$ was accepted

$Y = 1$ if $Y_1^* > 0 \Rightarrow$ the offer $P_{s,1}$ was rejected.

If $Y_1^* > 0$, so that $P_{s,1} > P_{d,1}$, then the buyers will reject the sellers' opening price offer. In this case, the bargaining process will continue and the seller must make a second price offer in order to reach a price agreement. Viewing the sellers' second price offer as an adjustment to his or her first price offer, it can be expressed as the sellers' supply price plus an adjustment increment that is less than or equal to the increment added to P_s in the previous offer.

(17)
$$\begin{aligned} P_{s,2} &= [P_s + \Delta P_{s,2}] + \varepsilon_{s,2} \\ &= [f_s(X) + \varepsilon_s] + [\Delta f_{s,2}(X) + \Delta\varepsilon_{s,2}] + \varepsilon_{s,2} \\ &= [f_s(X) + \Delta f_{s,2}(X) + [\varepsilon_s + \Delta\varepsilon_{s,2} + \varepsilon_{s,2}] \\ &= f_{s,2}(X) + \varepsilon^*_{s,2} \end{aligned}$$

or

(18) $P_{s,2} = f_{s,2}(X) + \varepsilon^*_{s,2}$, with $E[\varepsilon^*_{s,2}] = 0$ and $Y_1^* > 0$

Similarly, the buyers' second threshold price can be defined as an adjustment of the first threshold price. It can be represented as the buyers' demand price less an increment that is greater than or equal to the increment in the previous threshold price function, such as:

(19)
$$\begin{aligned} P_{d,2} &= [P_d - \Delta P_{d.2}] + \varepsilon_{d,2} \\ &= [f_d(X) + \varepsilon_d] - [\Delta f_{d,2}(X) + \Delta\varepsilon_{d,2}] + \varepsilon_{d,2} \\ &= [f_d(X) - \Delta f_{d,2}(X) + [\varepsilon_d - \Delta\varepsilon_{d,2} + \varepsilon_{d,2}] \\ &= f_{d,2}(X) + \varepsilon^*_{d,2} \end{aligned}$$

or

(20) $P_{d,2} = f_{d,2}(X) + \varepsilon^*_{d,2}$, with $E[\varepsilon^*_{d,2}] = 0$ and $Y_1^* > 0$.

While it is impossible to know if there is any change in the buyers' threshold price during the bargaining process since the threshold price cannot be observed, it is reasonable to assume that the buyers will consider adjusting their threshold price based on previous bargaining outcomes. If the buyers' second threshold price is the same as the first in the bargaining process, then $\Delta P_{d,2} = \Delta P_{d,1}$, and the threshold price will be:

(21) $P_{d,2} = P_{d,1} = f_{d,1}(X) + \varepsilon^*_{d,1}$

The criterion function for the second round price negotiation can be defined as the difference between the sellers' second price offer and the buyers' second threshold price:

(22) $Y_2^* = P_{s,2} - P_{d,2} = f_2(X) + \varepsilon^*_2$

If $Y_2^* > 0$, so that $P_{s,2} > P_{d,2}$, then the buyer will reject the sellers' second price offer. In this case, the price discovery process continues. A final price will be determined by an arbitration board based on the sellers' second price offer, the buyers' response to that offer, and perceptions of market conditions. If $Y_2^* \leq 0$, then the sellers' second price offer will be accepted. The final price will be the sellers' second price offer, given by equation (18).

In this study, it can be assumed that the final price resulting from the bargaining process is either the sellers' first or second price offer in view of the fact that the bargaining process for processing asparagus resulted in at most two different price possibilities in each year. Based on this assumption, an econometric model of price discovery for processing asparagus under bargaining was specified as:

(23) $P_{s,1} = f_{s,1}(X) + \varepsilon^*_{s,1}$ $E(\varepsilon^*_{s,1}) = 0$

$P_{s,2} = f_{s,2}(X) + \varepsilon^*_{s,2}$ $E(\varepsilon^*_{s,2}) = 0$, given $Y_1^* = f_1(X) + \varepsilon_1^* > 0$

$P_f^* = (1-\delta)\, P_{s,1} + \delta\, P_{s,2}$

where δ is a dichotomous variable which is defined in such a way that $\delta = 0$ when the sellers' first price offer is accepted and $\delta = 1$ if the second offer is accepted.

Estimation of the Bargaining Model

The sellers' first offer equation can be estimated via using ordinary least squares (OLS) using all of the observations on first offers since the equation satisfies all of the usual OLS assumptions. The second offer equation should not be estimated with OLS because of the obvious censoring problem that underlies its specification. The sellers' second price offer equation meets the conditions of, and is estimated using, Heckman's two-stage estimation procedure. In particular, assuming multivariate normality of disturbances, the expected value of the seller's second offer can be represented as (recall equation (13))

$$(24) \quad E(P_{s,2} \mid (Y_1^* > 0) = f_{s,2}(X) + E(\varepsilon^*_{s,2} \mid \varepsilon_1^* > -f_1(X))$$

$$= f_{s,2}(X) + \tau(\phi/\Phi)$$

where ϕ and Φ are the probability density and cumulative distribution function of the standard normal distribution evaluated at the point $-f_1(X)/\tau$, and τ is the covariance between ε_1^* and $\varepsilon^*_{s,2}$.

The estimation of the seller's second offer equation then proceeds in two steps. In the first step, a probit model is fit to dichotomous observations indicating whether or not the first offer was accepted, and is based on the universal set of explanatory variables, X. Then the predicted Mill's ratios (ϕ/Φ) are used as an additional explanatory variable in estimating the seller's second offer equation via least squares. That is, a Heckman two-step procedure is used to estimate the seller's second offer equation.

Based on annual time series data from 1960 to 1994 on price offers and acceptances, the estimated equations for the asparagus growers' first and second price offers are (t-ratios are in parentheses):

$$(25) \quad \underset{}{PPW_{1t}} = 5.9 - \underset{(-2.7)}{0.1\ AW_t} - \underset{(-1.7)}{0.02\ SPU_{t-1}} + \underset{(2.7)}{0.13\ PFU_{t-1}} + \underset{(3.5)}{0.72\ PPU_{t-1}}$$

$R^2 = 0.93$, Durbin Watson (d) = 1.8, Std. Error of the Estimate = 1.4

$$(26) \quad PPW_{2t} = 35.0 - \underset{(-3.2)}{1.03\ AW_t} - \underset{(-2.1)}{0.12\ SPU_{t-1}} + \underset{(2.5)}{0.17\ PFU_{t-1}} - \underset{(-3.9)}{0.88\ PPU_{t-1}}$$

$$-12.2\ \text{Mills}_t$$
$$(-2.0)$$

$R^2 = 0.89$, Durbin Watson (d) = 1.7, Std. Error of the Estimate = 1.0

where,

AW_t = Bearing acreage of asparagus for the coming season in Washington;

SPU_{t-1} = Previous year's ending stock of U.S. processed asparagus;

PFU_{t-1} = Previous year's U.S. price of fresh asparagus;

PPU_{t-1} = Previous year's U.S. price of processing asparagus;

PPW_t = The final price of processing asparagus in Washington/Oregon; and

$Mills_t$ = Mills ratio correction term in the Heckman two-step procedure.

The probit model underlying the generation of the Mills' ratio correction in the seller's second offer equation is given by:

$$Y_1^* = -4.13 + .15\ Aw_t + .032\ SPU_{t-1} + .012\ PFU_{t-1} - .05\ PPU_{t-1}$$
$$(1.3) \qquad (1.5) \qquad (.22) \qquad (-.5)$$

LRT (4 df) = 6.84, Craig-Uhler $R^2 = .25$, Correct Predictions = 67%

Discussion

The signs of the coefficients on AW_t and SPU_{t-1} are negative in the first price offer equation estimated, indicating that the larger the current bearing acreage and carry-in stocks, the lower the price offer for processing asparagus will be. This is consistent with the notion that the bargaining strength of growers is eroded when supplies for the current market period are expected to be high. The perception of a diminished bargaining position is translated into a reduction in the initial price offer issued by growers. A positive sign is associated with the effects of both PPU_{t-1} and PFU_{t-1}. This is consistent with the notion that growers' expectations of current period prices for fresh and processed asparagus are extrapolated from their most recent experience. Higher price expectations for either fresh or processed asparagus induces growers to issue higher initial price offers.

The interpretations of the signs of the effects of AW_t, SPU_{t-1}, and PFI_{t-1} on the level of the second price offer by growers is analogous to the preceding interpretations in the case of the first price offer. Namely, expectations of higher asparagus supplies lead to lower levels of second price offers, while expectations of higher fresh market prices lead to higher second price offers. The negative sign on PPU_{t-1} was not anticipated, and indicates that at the second stage of the bargaining process, higher processed asparagus prices in the previous year induces lower values for growers' second price offer. The mills ratio is significant and has a negative effect, suggesting that the self-selection correction is relevant and that the relationship between disturbances in the probit and second price offer equations is negative, which makes intuitive sense.

Based on one-sided t tests, all of the t values for the explanatory variables in the econometric model are statistically significant at the level of $\alpha = 0.05$. Thus, the variables in the model can be considered as having significant influences on the offer prices for processing asparagus formulated during the bargaining process.

The estimated coefficients of the probit model indicate that the probability of the bargaining process going beyond the first round increases as expected supplies increase, which relates to increasing values of AW_t and SPU_{t-1}. This is consistent with the bargaining process between growers and processors becoming more contentious when high expected supplies place downward pressure on asparagus prices. The coefficient on lagged prices are notably insignificant, although the values of the estimated coefficients themselves suggest that it is more likely that the bargaining process will exceed one round if expectations of fresh asparagus prices are high and processed asparagus prices are low, which is sensible.

While the implications of the estimated probit equation are consistent with expectations, the model fit is considerably less than desirable. The likelihood ratio test on the significance of the explanatory variables has a probability value of only .13, and the ability of the model to predict an extended bargaining situation is disappointing. It is evident that factors beyond those included in the model exert important influences on the bargaining process.

Conclusions

The empirical bargaining model of price discovery in the Washington/Oregon Asparagus Industry identified a number of broad market indicators that exerted important influences on the bargaining process leading to an equilibrium processed asparagus price. Expected levels of supplies played a notable role in the levels of price offers throughout the bargaining process, and also appeared to influence whether the bargaining process required more than one round to complete. Past prices of asparagus in the fresh and processed markets also influenced price offers, but their affect on extending the bargaining process was unclear. The results of the model also suggest that other factors beyond broad market indicators influence the bargaining process, the most notable deficiency being in the explanation of the process leading to an extension of the bargaining process beyond the first round of negotiations.

TABLE 1: Market Equilibrium and Disequilibrium Situations

1. Market equilibrium			**2. Quantity Disequilibrium**	
$D=D(P_d, X)$	Demand		$D=D(P_d, X)$	Demand
$S=S(P_s, Y)$	Supply		$S=S(P_s, Y)$	Supply
$D=S=Q^*$	Quantity Equilibrium		$D \neq S \neq Q^*$	Quantity Bargaining
$P_d=P_s=P^*$	Price Equilibrium		$P_d=P_s=P^*$	Price Equilibrium
3. Price Disequilibrium			**4. Price and Quantity Disequilibrium**	
$D=D(P_d, X)$	Demand		$D=D(P_d, X)$	Demand
$S=S(P_s,Y)$	Supply		$S=S(P_s, Y)$	Supply
$D=S=Q^*$	Quantity Equilibrium		$D \neq S \neq Q^*$	Quantity Bargaining
$P_d \neq P_s \neq P^*$	Price Bargaining		$P_d \neq P_s \neq P^*$	Price Bargaining

NOTE: P_d = the buyers' price; P_s = the sellers' price; S = the quantity supplied; D = the quantity demanded; P^* = the bargained or equilibrium price; Q* = the bargained or equilibrium quantity; X = demand shifters; and Y = supply shifters.

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