AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

Journal of Agricultural and Resource Economics 21(2):235–246
Copyright 1996 Western Agricultural Economics Association

Identifying Implicit Collusion under Declining Output Demand

Ananda Weliwita and Azzeddine Azzam

The "trigger price" oligopoly model is used to develop a test for oligopolistic as well as oligopsonistic conduct by observing how an industry responds to unexpected declines in output demand. The hypothesis that U.S. beef packers maintain cooperative pricing strategies is rejected.

Key words: beef packing, oligopoly, oligopsony, trigger price

Introduction

Baker's empirical "trigger price" oligopoly model is used to develop a test of oligopolistic as well as oligopsonistic conduct by observing industry's response to unexpected declines in output demand. The basic idea behind the model, introduced earlier by Green and Porter, is that an industry behaving as a cartel will be more competitive after a large unexpected decline in output demand. This behavior is interpreted as a punishment mechanism practiced by members of a cartel who cannot distinguish between negative demand shocks and rival cheating. This article makes inference about cartel conduct in the U.S. beef packing industry by testing whether the industry's oligopoly markup and oligopsony markdown decrease following large unexpected declines in beef demand.

Concern about oligopoly/oligopsony in the beef packing industry has prompted several empirical studies. The change in the structure of the industry, however, occurred in concert with declining demand for red meat, beef in particular. The link between industry oligopoly/oligopsony conduct and beef demand, however, has yet to be explored. Live-cattle supply effects on packer conduct have been the focus of two past studies (Koontz, Garcia, and Hudson; Stiegert, Azzam, and Brorsen). Other studies estimated the size of the oligopsony distortions (Azzam; Azzam and Park; Schroeter; Schroeter and Azzam). Koontz, Garcia, and Hudson's study, which also uses the "trigger price" model, infers the degree of oligopsony power using day-to-day movement in regional beef margins. Packers were assumed to be price takers in the beef market. Koontz, Garcia, and Hudson found beef-packer oligopsony alternated between periods of cooperative and noncooperative pricing conduct. Stiegert, Azzam, and Brorsen used national data to study the effect on packer conduct of inadequate cattle supply. Shortfalls in cattle supply induced packers to increase the markdown, apparently to ensure a margin adequate to cover processing costs.

While cattle supply is undoubtedly important in determining industry conduct, beef

---

The authors are, respectively, a postdoctoral research associate in the Department of Agricultural Economics and Marketing, Rutgers University, and professor in the Department of Agricultural Economics, University of Nebraska-Lincoln.

The authors benefitted from comments by Jeffrey Royer, James Schmidt, Everett Van der Sluis, and two anonymous reviewers.

This is University of Nebraska-Lincoln Agricultural Research Division Journal Article No. 11263.

demand is postulated by industry observers as the single most important factor explaining the changing structure of the industry (Purcell). Although the intent of this article is not to empirically verify demand-induced structural change, it should provide some measure of demand-induced conduct. The findings should also contribute to the inventory of analyses of industry conduct using alternative oligopoly/oligopsony theories.

Conceptual Model

The model links three vertically related industries: cattle feeders, beef packers, and wholesalers/retailers. Cattle feeders are price takers and supply live cattle to beef packers. Packers combine the material input with nonmaterial inputs to produce dressed or boxed beef. Packers sell the beef to wholesalers/retailers. Packers are not necessarily price takers in the material input and output markets. They may oligopsonistically purchase live cattle and oligopolistically sell boxed beef. The beef-processing technology is assumed to be of fixed proportions.[1] This allows, with appropriate conversion, the output and the material input to be denoted by the same variable.

The hypothesis to be tested is that if packers follow cooperative pricing strategies in both cattle and beef markets, then they temporarily revert to competitive pricing after unexpected declines in beef demand. Reversion to competitive pricing during periods of uncertainty is interpreted as a policing mechanism to punish cheating by rival packers. Firms behave this way because they are unable to distinguish between unexpected demand declines and rival cheating. Competitive pricing following large unexpected declines in demand implies shrinking packer oligopoly markup and oligopsony markdown.[2]

To construct an empirically implementable model, let the inverse market demand D faced by the packing industry for processed beef be

$$D\colon P = f(Q, Y) + \epsilon, \tag{1}$$

and the inverse live-cattle industry supply curve S be

$$S\colon W = g(Q, Z) + \nu, \tag{2}$$

where P, Q, and W are retail price of beef, quantity of beef, and price of live cattle, respectively. The vectors Y and Z include exogenous shifters of beef demand and live-cattle supply, respectively. The errors ϵ and ν represent random errors.

Industry marginal processing cost is

$$MPC = c^m(Q, G) + \lambda, \tag{3}$$

where G is a vector of nonmaterial inputs used in the processing of beef, and λ is a random shock.

Since the industry is not assumed to be a price taker in the beef market, the inverse demand function in (1) defines the following marginal revenue function:

[1] This assumption is appropriate if beef-packing firms cannot effect dressing yields in the short run. However, as Mullen, Wohlgenant, and Farris note, substitution possibilities may exist at the industry level even if the technology is of fixed proportions at the firm level. The authors also note that the boxed-beef technology itself has been a source of input substitution (p. 250).

[2] This result hinges on assuming that packers do not have perfect knowledge of cattle inputs and beef outputs of their rivals. If packers did indeed know about their rivals' inputs and outputs, as one reviewer contends, then the applicability of the Green-Porter model to the beef industry is questionable.

$$MR = f(Q, Y) + Qf_q(Q, Y) + \epsilon, \tag{4}$$

where $f_q(Q, Y)$ is the slope of the demand function. Similarly, the live-cattle supply function in (2) defines the marginal expenditure function:

$$ME = g(Q, Z) + Qg_q(Q, Z) + \nu, \tag{5}$$

where $g_q(Q, Z)$ is the slope of the live-cattle supply function.

Total marginal cost (MC) is the sum of marginal processing cost (MPC) and marginal expenditure on live cattle (ME). Equality of MR and MC implies

$$f(Q, Y) + Qf_q(Q, Y) + \epsilon = c^m(Q, G) + \lambda + Qg_q(Q, Z) + g(Q, Z) + \nu. \tag{6}$$

Denoting the margin $P - W$ by M, letting $Qf_q(Q, Z) = MR - P$ [from (4)], $Qg_q(Q, Z) = ME - W$ [from (5)], and rearranging terms in (6) results in the margin relation:

$$M = \theta(P - MR) + \gamma(ME - W) + c^m(Q, G) + \lambda, \tag{7}$$

where $\theta(P - MR)$ is the oligopoly distortion, and $\gamma(ME - W)$ is the oligopsony distortion. The parameters θ and γ index oligopoly and oligopsony conduct, respectively. If $\theta = \gamma = 0$, the margin, M, equals marginal processing cost, implying perfect competition. In the pure monopoly/monopsony case ($\theta = \gamma = 1$), the margin exceeds that under the perfectly competitive case by the monopoly markup ($P - MR$) and the monopsony markdown ($ME - W$). Values between 0 and 1 for θ and γ represent the industry's average index of oligopolistic and oligopsonistic conduct in the beef and cattle market, respectively.

To establish how demand shocks effect the margin through their effects on the conduct parameters θ and γ, use (4) and (5) and rewrite (7) as follows:

$$M = -\theta(\epsilon)Qf_q(Q, Y) + \gamma(\epsilon)Qg_q(Q, Z) + c^m(Q, G) + \lambda, \tag{8}$$

where θ and γ are now functions of the demand shocks ϵ. Also, since $W = P - M$, rewrite (2) as

$$P = M + g(Q, Z) + \nu. \tag{9}$$

Total differentiation of (1), (8), and (9), holding Y, Z, G, λ, and ν constant, yields

$$dP = f_q dQ + d\epsilon, \tag{10}$$

$$dP = g_q dQ + dM + d\nu, \tag{11}$$

and

$$dM = -\theta f_q dQ - \theta Q f_{qq} dQ - Qf_q \theta_\epsilon d\epsilon + \gamma g_q dQ + \gamma Q g_{qq} dQ + Qg_q \gamma_\epsilon d\epsilon + c_q dQ + d\lambda, \tag{12}$$

where $f_q = \partial f(Q, Y)/\partial Q$, $f_{qq} = \partial^2 f(Q, Y)/\partial Q^2$, $g_q = \partial g(Q, Z)/\partial Q$, $g_{qq} = \partial^2 g(Q, Z)/\partial Q^2$, $c_q = \partial c^m(Q, G)/\partial Q$, $\theta_\epsilon = \partial\theta/\partial\epsilon$, and $\gamma_\epsilon = \partial\gamma/\partial\epsilon$. Arranging (10), (11), and (12) in matrix form gives

$$\begin{bmatrix} 1 & -f_g & 0 \\ 1 & -g_g & -1 \\ 0 & T_1 & 1 \end{bmatrix} \begin{bmatrix} dP \\ dQ \\ dM \end{bmatrix} = \begin{bmatrix} d\epsilon \\ d\nu \\ T_2 \end{bmatrix}, \tag{13}$$

where

$$T_1 = \theta(f_q + Qf_{qq}) - \gamma(g_q + Qg_{qq}) - c_q,$$

and

$$T_2 = -(Qf_q\theta_\epsilon - Qg_q\gamma_\epsilon)\, d\epsilon + d\lambda.$$

Under the null hypothesis that conduct does not vary with ϵ, that is $\theta_\epsilon = \gamma_\epsilon = 0$, the response of the margin to the demand shock is

$$\frac{dM_1}{d\epsilon} = \frac{c_q - \theta(f_q + Qf_{qq}) + \gamma(g_q + Qg_{qq})}{c_q + g_q - f_q - \theta(f_q + Qf_{qq}) + \gamma(g_q + Qg_{qq})}. \tag{14}$$

If conduct does respond to demand shocks, that is, $\theta_\epsilon \neq 0$ and $\gamma_\epsilon \neq 0$, the response of the margin to the demand shock is

$$\frac{dM_2}{d\epsilon} = \frac{c_q - \theta(f_q + Qf_{qq}) + \gamma(g_q + Qg_{qq})}{c_q + g_q - f_q - \theta(f_q + Qf_{qq}) + \gamma(g_q + Qg_{qq})} + \frac{-g_q(Qf_q\theta_\epsilon - Qg_q\gamma_\epsilon) + f_q(Qf_q\theta_\epsilon - Qg_q\gamma_\epsilon)}{c_q + g_q - f_q - \theta(f_q + Qf_{qq}) + \gamma(g_q + Qg_{qq})}. \tag{15}$$

In general, the sign of $dM_1/d\epsilon$ in (14) will be positive when demand and supply curves are linear so that $f_{qq} = g_{qq} = 0$, the demand curve is downward sloping ($f_q<0$), and the supply curve is upward sloping ($g_q>0$).[3]

Since the right-hand-side first term of (15) and the right-hand side of (14) are the same and the additional term of (15) is positive, the term $dM_2/d\epsilon$ is also positive but larger than $dM_1/d\epsilon$. Therefore, if unexpected declines in demand are measured as large negative values for ϵ, then the margin declines more when θ and γ vary with ϵ than when they do not vary with ϵ. This forms the basis for the hypothesis test.

Empirical Model

To estimate industry's response in input and output markets to unanticipated declines in beef demand, an econometrically estimable version of (7) is needed. Assume beef demand and live-cattle supply, respectively, take the linear forms:

$$P_B = \alpha_0 + \alpha_1 Q_B + \alpha_2 Q_P + \alpha_3 Q_C + \alpha_4 I + \epsilon, \tag{16}$$

and

$$Q_B = \beta_0 + \beta_1 W_C + \beta_2 W_{PC} + \beta_3 W_F + \nu, \tag{17}$$

where P_B is the wholesale price of beef; Q_B, Q_P, and Q_C are per capita consumption of beef, pork, and chicken, respectively; I is per capita disposable income; W_C is the price of cattle received by farmers; W_{PC} is price of corn; and W_F is price of feeder cattle. The α_is, and β_is are parameters to be estimated. The error terms are denoted by ϵ and ν. Given the demand function (16), the perceived marginal revenue defined by (4) becomes

$$MR = P_B + \alpha_1 Q_B. \tag{18}$$

[3] Subscript 1 in (14) indicates θ and γ are constant, and subscript 2 in (15) indicates θ and γ vary with ϵ.

Similarly, given the live-cattle supply function (17), the marginal expenditure function in (5) becomes

$$ME = W_C + \frac{Q_B}{\beta_1}. \tag{19}$$

Marginal processing cost, *MPC*, is assumed to take the linear form:

$$MPC = \delta_0 + \delta_1 Q_B + \delta_2 COST + \lambda, \tag{20}$$

where *COST* is an index of marketing costs. Making use of (18), (19), and (20), the margin relation in (7) can now be rewritten as:

$$M = \delta_0 + (\delta_1 - \theta\alpha_1 + \gamma\beta_1)Q_B + \delta_2 COST + \lambda. \tag{21}$$

When θ and γ do not vary with the exogenous variables in the demand and supply equations, the linear demand and live-cattle supply functions allow identifying the margin relation in (21) with exclusion restrictions. Although the margin relation is identified, it is not possible to disentangle θ and γ, even though estimates for α_1 and β_1 can be obtained by estimating demand and supply equations, separately. To identify θ and γ, a rotation in both the demand and supply equations are required (Bresnahan; Azzam and Park). The rotation of the demand equation can be achieved by including an interaction term into (16) involving Q_B and an exogenous variable (e.g., I). The new demand function becomes

$$P_B = \alpha_0 + \alpha_1 Q_B + \alpha_2 Q_P + \alpha_3 Q_C + \alpha_4 I + \alpha_6 Q_B I + \epsilon. \tag{22}$$

The perceived marginal revenue function associated with (22) is

$$MR = P_B + Q_B(\alpha_1 + \alpha_6 I). \tag{23}$$

Similarly, the supply curve can be rotated by including an interaction term in (17) involving W_C and an exogenous variable. The price of diesel, W_{DS}, a proxy for transportation cost, was chosen for the interaction term.[4] The new supply function is

$$Q_B = \beta_0 + \beta_1 W_C + \beta_2 W_{PC} + \beta_3 W_F + \beta_4 W_C W_{DS} + \nu. \tag{24}$$

The marginal expenditure function associated with the new supply function is

$$ME = W_C + \frac{Q_B}{(\beta_1 + \beta_4 W_{DS})}. \tag{25}$$

Making use of (23) and (25), the margin relation in (21) becomes

$$M = \delta_0 + \theta Q_1^* + \gamma Q_2^* + \delta_1 Q_B + \delta_2 COST + \lambda, \tag{26}$$

where $Q_1^* = -Q_B(\alpha_1 + \alpha_6 I)$, and $Q_2^* = Q_B/(\beta_1 + \beta_4 W_{DS})$. The coefficients of Q_1^* and Q_2^* (θ and γ) are measures of industry conduct in the beef and cattle markets, respectively. The margin relation in (26) consists of three components: an oligopoly markup (θQ_1^*), an oligopsony markdown (γQ_2^*), and marginal processing cost ($\delta_0 + \delta_1 Q_B + \delta_2 COST + \lambda$).

[4] Necessary and sufficient conditions for identifying the degree of competitiveness in the output market from industry price and output data are presented in Lau. For oligopoly, this is achieved by employing an inverse demand function which is separable in exogenous variables. In the case of oligopsony, the condition requires an inclusion of an interaction term in the supply function (Azzam and Park).

To test the hypothesis that industry conduct becomes more competitive following unexpected declines in beef demand, θ and γ are assumed to be linear functions of the demand shocks, namely,

$$\theta = \theta^* + \eta\epsilon, \tag{27}$$

and

$$\gamma = \gamma^* + \mu\epsilon, \tag{28}$$

where θ^* and γ^* are intercepts, and η and μ are slopes. Substitution of (27) and (28) into (21) yields

$$M = \delta_0 + \theta^* Q_1^* + \eta(\epsilon Q_1^*) + \gamma^* Q_2^* + \mu(\epsilon Q_2^*) + \delta_1 Q_B + \delta_2 COST + \lambda. \tag{29}$$

The hypothesis that industry conduct becomes more competitive in beef and cattle markets is equivalent to the hypothesis that η and μ are negative and significant, thus, lowering the industry margin following unexpected declines in beef demand.

Demand shocks will make firms behave more competitively only if they lead firms to suspect an increase in output by the competing firms. This implies that only large negative shocks affect θ and γ. Small unexpected demand shocks will not alter firm behavior since they will not be sufficiently large enough for firms to suspect an increase in output by competing firms. On the other hand, unanticipated increases in demand will not make firms act more competitively by producing more output because of the possibility that such behavior will trigger a price war.[5]

In order to determine how conduct is affected by large negative demand shocks, a dummy variable (*DUM*) is created from the vector of demand residuals (*RES*). The variable *DUM* takes a value of 1 when *RES* is a large negative number *in absolute value* and 0 for small negative values and for positive values of *RES*. Thus, *DUM* is triggered in periods during which the competing firms feel the greatest threat of increase in output by competing firms, hence the greatest incentive to increase their own output. Substituting *DUM* for ϵ in (27) and (28) yields

$$\theta = \theta^* + \eta DUM, \tag{30}$$

and

$$\gamma = \gamma^* + \mu DUM. \tag{31}$$

Incorporating (30) and (31) into (29) gives

$$M = \delta_0 + \theta^* Q_1^* + \eta DUM Q_1^* + \gamma^* Q_2^* + \mu DUM Q_2^* + \delta_1 Q_B + \delta_2 COST + \lambda. \tag{32}$$

The comparative statics showed the decline in the margin is steeper when θ and γ vary with ϵ than when they do not vary with ϵ [compare (14) and (15)]. Comparison of (26) and (32) will verify this proposition. Equation (32) is (26) plus the two additional terms, $\eta DUMQ_1^*$ and $\mu DUMQ_1^*$. Since they are both negative (because $\eta<0$ and $\mu<0$), the margin in (32) is smaller than the margin in (26). In other words, when unexpected demand declines are large enough to trigger the dummy variable to take the value of

[5] There exists no relationship between the size of the triggering demand shocks and the length of the resulting price war (Porter). Stated differently, once an unexpected price decline is large enough to create a suspicion in firms of increase in output by competing firms, the duration of firms' competitive behavior does not vary with the size of the triggering demand shock.

one, firms in the industry respond by becoming more competitive, thus lowering the margin.

The variable *DUM* is created according to the following rule:

$$DUM = 1 \quad \text{if } \epsilon < -Ts, \qquad (33)$$
$$= 0 \quad \text{if } \epsilon \geq -Ts,$$

where T is a scalar, and s is the estimate of the standard error of the beef demand. According to (33), the variable *DUM* takes the value of 1 when ϵs in the *RES* vector are greater *in absolute value* than Ts, and the value of 0 for all the other ϵs. When $T = 0$, *DUM* will take the value 1 for all the negative demand shocks and 0 for all nonnegative demand shocks. Hence, zero is the lower bound for T which ensures that *DUM* will be triggered for all the negative demand shocks. The upper bound for T is $-\epsilon/s$, and this T value will be associated with the largest negative demand shock *in absolute value.*[6]

Having established the range for T, a grid search is used to search for the T value that maximizes the likelihood of observing the supply equation (24) and the margin relation (32). The hypotheses that $\eta<0$ and $\mu<0$ are individually tested using one-tailed t-test against the null hypotheses that $\eta = 0$ and $\mu = 0$.

The full model is

$$P_B = \alpha_0 + \alpha_1 Q_B + \alpha_2 Q_P + \alpha_3 Q_C + \alpha_4 I + \alpha_5 Q_B I + \epsilon, \qquad (34)$$

$$Q_B = \beta_0 + \beta_1 W_C + \beta_2 W_{PC} + \beta_3 W_F + \beta_4 W_C W_{DS} + \beta_5 Q_{B,t-1} + \nu, \qquad (35)$$

and

$$M = \delta_0 + \theta^* Q_1^* + \eta DUMQ_1^* + \gamma^* Q_2^* + \mu DUMQ_2^* + \delta_1 Q_B + \delta_2 COST + \lambda. \qquad (36)$$

The demand equation (34) includes interaction between per capita income I and per capita consumption of beef Q_B, seasonal dummies (D_2, D_3, and D_4) representing second, third, and fourth quarters, and per capita consumption of pork and chicken. In the quantity dependent live-cattle supply function (35), price of corn (W_{PC}) and price of feeder cattle (W_F) are supply shifters. The lagged dependent variable ($Q_{B,\,t-1}$) accounts for the effects of long-term trends in the live-cattle supply. Prices of live cattle, corn, and feeder cattle are converted to averages of the current and the previous three quarters to capture the effect of price expectations on cattle supply (Marsh; Freebairn and Rausser). The marketing cost index, *COST,* in (36) is a weighted average of food processing input prices (Harp). All price variables were deflated by the GNP implicit price deflator (U.S. Department of Commerce).[7] Quarterly data for the period 1978.I through 1993.III were used for the analysis. Description of the variables and sources of data are listed in table 1.

Results

Since residuals from the demand equation are needed to create the variable *DUM,* the demand equation must be estimated separately from the rest of the system. However,

[6] This is the same criterion used by Baker.

[7] The model was also estimated using nominal prices. Though the coefficient estimates were, as expected, different from the model using real prices, results of the hypothesis tests were qualitatively the same. The results reported in this article are those obtained from the model with real prices. Those using nominal prices are reported in Weliwita.

Table 1. Variable Names, Definitions, Units of Measure, and Sources

Variable	Definition	Unit	Source[a]
P_B	Estimated weighted average wholesale price of choice yield grade 3 beef	cents/lb.	LPS
W_C	Beef net farm value = market value to producer of 2.4 lb. live animal, equivalent to 1 lb. of retail cuts, minus farm by-product allowance	cents/lb.	White et al. and LPS
M	Farm-wholesale marketing margin = $P_B - W_C$	cents/lb.	LPS
Q_B	U.S. per capita commercial beef production	lbs., retail weight	LPS
Q_P	U.S. per capita commercial pork production	lbs., retail weight	LPS
Q_C	U.S. per capita commercial chicken production	lbs., retail weight	LPS
I	Per capita aggregate disposable personal income	$	LPS
W_{PC}	Price of corn	$/bu.	AGOUT
W_F	Price of feeder steers, choice (Kansas City)	600–700 lb.	LPS
W_{DS}	Wholesale price of No. 2 diesel fuel	cents/gal, tax excluded	MER
$COST$	Food marketing cost index	1967 = 100	Harp

[a] LPS is USDA/ERS, *Livestock and Poultry Situation and Outlook*; AGOUT is USDA/ERS, *Agricultural Outlook*; and MER is USDA/EIA, *Monthly Energy Review*.

demand shocks are not independent of supply shocks if the covariance matrix of supply and demand residuals is not diagonal. Using Breusch and Pagan's test, the null hypothesis of a diagonal covariance matrix was not rejected at the 5% level.[8]

The two-stage least squares estimates of the demand function are presented in table 2. The model was tested for first-order serial correlation using the Durbin-Watson statistic. The test statistic (1.85) falls within the inconclusive range. All coefficients are statistically significant at the 5% level, except the own slope and the third- and fourth-quarter seasonal dummies.

Nonlinear three-stage least squares (3SLS) estimates of the supply equation and the margin relation are presented in table 3. The system fits the data well. The McElroy's system R^2 is 0.86. The coefficient for the cost index was negative but not significant. Time was included to account for long-term trends in marginal processing cost. A negative and marginally significant coefficient for time indicates a shift in marginal processing cost over the sample period. The coefficient for Q_B in the margin relation represents the slope of the marginal processing cost. This coefficient is not significantly different from zero. It may be that the marginal processing cost function is horizontal over the range of the data.

Table 3 also shows that both η and μ are not different from zero, implying that unexpected declines in demand for beef did not enhance the degree of industry competition in beef and cattle markets. In other words, packers did not maintain a cooperative pricing strategy in cattle and beef markets. Table 4 reports two subsidiary tests of price-taking behavior in input and output markets. The price-taking hypothesis in the output market is tested by testing the restriction that $\theta^* = \eta^* = 0$. Similarly, the price-taking

[8] The chi-squared statistic is 0.397 and the critical value with one degree of freedom is 3.84.

Table 2. Results of 2SLS Estimation of the Beef Demand Equation (34)

Variable	Parameter Estimate	t-Ratio
Intercept	0.758	2.211[b]
Q_B	0.012	0.505
Q_P	−0.007	−0.548
Q_C	−0.069	−4.899[a]
I	21.516	6.059[a]
Q_B^*I	−0.530	−3.778[a]
D_2	0.159	3.730[a]
D_3	0.078	1.641
D_4	0.027	0.596
R^2	0.905	
DW	1.852	
N	59	

[a] Denotes significance from zero at 1% level with a two-tailed t-test.
[b] Denotes significance from zero at 5% level with a two-tailed t-test.

Table 3. Joint Estimation Results of Fed Cattle Supply (35) and Margin Relation (36) Using Nonlinear 3SLS

Variable	Parameter Estimate	t-Ratio
Supply:		
Intercept	2,896.15	4.11[a]
W_C	3,025.74	3.21[a]
W_{PC}	16,972.66	1.22
W_F	−4,102.14	−3.11[a]
W_c^*WDS	−709.496	−2.38[b]
$Q_{B,t-1}$	0.299	2.13[b]
D_2	214.155	2.30[b]
D_3	397.531	4.63[a]
D_4	269.208	3.18[a]
Margin Relation:		
Intercept	0.734	1.53
Q_1^*	0.662	1.30
$DUM^*Q_1^*$	−0.035	−0.34
Q_2^*	0.0003	1.04
$DUM^*Q_2^*$	0.0001	1.07
Q_B	−0.0002	−1.25
$COST$	−0.085	0.121
$TIME$	−0.045	−1.62
McElroy's R^2	0.86	
N	60	

[a] Denotes significance from zero at 1% level with a two-tailed t-test.
[b] Denotes significance from zero at 5% level with a two-tailed t-test.

Table 4. Hypotheses Testing for Degree of Competiveness in Input and Output Markets

Hypothesis	Computed χ^2	Critical $\chi^2_{2,.05}$	Conclusion
Perfect competition in output market (H_0: $\theta^* = \eta^* = 0$)	4.4611 18.1652	5.99	Reject H_0
Perfect competition in input market (H_0: $\gamma^* = \mu^* = 0$)	1.55	5.99	Do not reject H_0
Degree of competition in output market	$\theta = 0.659$ (1.60)		
Degree of competition in input market	$\gamma = 0.004$ (1.09)		

Note: Figures in parentheses are asymptotic t-ratios.

hypothesis in the input market is tested by imposing the restriction $\gamma^* = \mu^* = 0$. While competition in the beef market is rejected, it was not rejected in the cattle market. The estimated oligopoly distortion, as a percentage of the margin, is in the neighborhood of 2.7%.[9]

Findings of the present study are brought into light in conjunction with some of the previous market power studies in beef packing (table 5). At least one of the objectives of all the various studies was to test the price-taking hypothesis in beef/cattle markets. Though these studies differ widely with respect to analytical method, type of data, and period of study, the findings, in general, are not consistent with perfect competition.

[9] The average distortion, as a percentage of the margin, was calculated as $(\theta^* Q_1^* + \eta DUMQ_1^*)/M$.

Table 5. Summary Results of NEIO Studies of Beef Packing

Author(s)	Type of Data[a]	Sample Period	Distortion	Findings[b]
Schroeter	A, N	1951–83	3%(WH), 1%(FC)	FC(yes), WH(yes)
Schroeter and Azzam	Q, N	1976.I–86.IV	14%(WH), 13%(FC) 55% of margin	FC(yes), RE(yes)
Stiegert et al.	Q, N	1972.I–86.IV	1.31%(FC)	FC(yes)
Azzam	M, N	Jan. 1988–Mar. 1991	Not available	FC(yes), WH(no)
Azzam and Park	A, N	1960–87	Not available	FC(no) 1960–77 FC(yes) 1978–87
Koontz et al.	D	July 1980–Sep. 1982 July 1984–July 1986	\$5–19/head (1984–86) \$2–5/head (1980–82)	FC(yes)
This article	Q, N	1978.I–93.III	2.7% (Farm WH margin)	FC(no), WH(yes)

[a] A = annual, Q = quarterly, M = monthly, D = daily, N = national, FC = fed-cattle market, WH = wholesale market, RE = retail market.
[b] Yes = evidence for market power, No = no evidence for market power.

Results of the present study do not, however, provide evidence that packer conduct is noncompetitive in the cattle market. However, evidence that packers exercise market power in the beef market is in concert with the findings of many previous studies.

Summary and Conclusions

The objective of this article was to make inference about market conduct in input and output markets from observing how an industry responds to unexpected declines in demand. The technique, an extension of a "trigger price" oligopoly model, tests the hypothesis that firms behave more competitively in both input and output markets following large unexpected declines in demand. The model is based on the proposition that when firms do not have perfect information about their rivals, oligopoly/oligopsony behavior is influenced by inferences firms make about rival behavior following random declines in demand.

Results do not provide evidence that packer conduct in beef and cattle markets became more competitive following large unexpected declines in beef demand. Thus, the hypothesis that packers maintain cooperative pricing strategies in cattle procurement and beef sale is rejected. This result is consistent with Koontz, Garcia, and Hudson's findings using more disaggregated data.

Two auxiliary tests were conducted to test price-taking behavior. Packer oligopoly in the beef market is not rejected. The oligopoly distortion, however, is smaller than those reported in previous studies. Packer oligopsony in cattle procurement is rejected.

[*Received April 1995; final version received February 1996.*]

References

Azzam, A. "Testing the Competitiveness of Food Price Spreads." *J. Agr. Econ.* 43(1992):248–56.

Azzam, A., and T. Park. "Testing for Switching Market Conduct." *Appl. Econ.* 25(1993):796–801.

Baker, J. "Identifying Cartel Policing under Uncertainty: The U.S. Steel Industry, 1933–1939." *J. Law and Econ.* 32(1989):S47–S76.

Breusch, T. S., and A. R. Pagan. "The Lagrange Multiplier Test and Its Applications to Model Specification in Econometrics." *Rev. Econ. Stud.* 47(1980):239–53.

Bresnahan, T. F. "The Oligopoly Solution Concept Is Identified." *Econ. Letters* 10(1982):87–92.

Freebairn, J. W., and G. C. Rausser. "Effects of Changes in the Level of U.S. Beef Imports." *Amer. J. Agr. Econ.* 57(1975):676–88.

Green, E., and R. Porter. "Non-Cooperative Collusion under Imperfect Price Information." *Econometrica* 87(1984):87–100.

Harp, H. "The Food Marketing Cost Index: A New Measure for Analyzing Food Price Changes." Tech. Bull. No. 1633, USDA/Economic Research, Washington DC, 1980.

Koontz, S. R., P. Garcia, and M. A. Hudson. "Meatpacker Conduct in Fed Cattle Price Pricing: An Investigation of Oligopsony Power." *Amer. J. Agr. Econ.* 75(1993):527–48.

Lau, L. "On Identifying the Degree of Competitiveness from Industry Price and Output Data." *Econ. Letters* 10(1982):93–99.

Marsh, J. M. "Estimating Intertemporal Supply Response in the Fed Beef Market." *Amer. J. Agr. Econ.* 76(1994):444–53.

Mullen, J. D., M. K. Wohlgenant, and D. E. Farris. "Input Substitution and the Distribution of Surplus Gains from Lower U.S. Beef-Processing Costs." *Amer. J. Agr. Econ.* 70(1988):245–54.

Porter, R. "On the Incidence and Duration of Price Wars." *J. Indus. Econ.* 33(1985):415–26.

Purcell, W. "Structural Change in the Livestock Sector: Causes, Implications, Continuing Issues." In *Structural Change in Livestock: Causes, Implications, Alternatives,* ed., W. Purcell, pp. 2–58. Research Institute on Livestock Pricing, February 1990.

Schroeter, J. R. "Estimating the Degree of Market Power in the Beef Packing Industry." *Rev. Econ. Statis.* 70(1988):158–62.

Schroeter, J. R., and A. Azzam. "Measuring Market Power in Multiproduct Oligopolies: The U. S. Meat Industry." *Appl. Econ.* 22(1990):1365–376.

Stiegert, K. W., A. Azzam, and B. W. Brorsen. "Markdown Pricing and Cattle Supply in the Beef Packing Industry." *Amer. J. Agr. Econ.* 75(1993):549–58.

U.S. Department of Agriculture, Economic Research Service. *Agricultural Outlook.* Washington DC: Government Printing Office. Various issues, 1985–93.

———. *Livestock and Poultry Situation and Outlook Report.* Washington DC: Government Printing Office. Various issues, 1990–93.

U.S. Department of Commerce, Bureau of Labor Statistics. *Survey of Current Business.* Washington DC: Government Printing Office. Various issues, 1985–93.

U.S. Department of Energy, Energy Information Administration. *Monthly Energy Review.* Washinton DC: Government Printing Office. Various issues, 1985–93.

Weliwita, A. "Identifying Implicit Collusion under Declining Output Demand: The Case of Beef Packing." Unpub. Ph.D. diss., University of Nebraska, Lincoln, 1995.

White, F. T., L. Duewer, J. Ginzel, R. Bohall, and T. Crawford. "Choice of Beef Prices and Price Spreads Series: Methodology and Revisions." Staff Rep. No. AGE9106, USDA/Economic Research, Washington DC, 1991.