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Abstract

A technique for assessing the degree of monopoly power, developed by Appelbaum (1979, 1982), is extended here to permit measurement of monopsony power as well. Data from the U.S. beef packing industry are examined. The results reveal small, but statistically significant monopoly/monopsony price distortions in slaughter cattle and wholesale beef markets but, in spite of a recent trend toward heightened concentration in the industry, give no indication that performance has become appreciably less competitive of late.

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ceteris paribus, executives are penalized at the margin, with reduced compensation, for achieving higher revenue growth. Third, these results suggest that managers are, at least partially, motivated by nonpecuniary motives (power and prestige) to maximize revenue. The Board, fearing this propensity to increase revenue growth beyond the profit maximizing rate, "penalizes" this revenue maximizing behavior with lower compensation. Rather than refuting the Baumol revenue maximization hypothesis, this study implicitly supports Baumol's central insight that managers may, indeed, have nonpecuniary incentives to increase revenue.

Furthermore, this study supports the view that Boards provide accounting profit maximization incentives to the CEO, which suggests that managers, as viewed by the Board, need this incentive to align their interests with those of the Board. We find that stock returns are not related to our measure of compensation. This finding indicates that either (1) Boards are not themselves value maximizers, and therefore, find no interest in aligning the CEO with this goal, or (2) Boards are value maximizers, but provide the CEO with other incentives for value maximization not included in our compensation measure such as stock options and stock ownership.

Finally, the results suggest that Boards of Directors have goals, as revealed by their compensation policies for the CEO, which are consistent with accounting profit maximization, and that are not consistent with revenue maximization. In the context of agency theory,

these findings support the view that owners, operating through their Boards, have a degree of control over these firms' managers for these time periods.

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ESTIMATING THE DEGREE OF MARKET POWER IN THE BEEF PACKING INDUSTRY

John R. Schroeter*

Abstract—A technique for assessing the degree of monopoly power, developed by Appelbaum (1979, 1982), is extended here to permit measurement of monopsony power as well. Data from the U.S. beef packing industry are examined. The results reveal small, but statistically significant monopoly/monopsony price distortions in slaughter cattle and wholesale beef markets but, in spite of a recent trend toward heightened concentration in the industry, give no indication that performance has become appreciably less competitive of late.

The structure of the beef packing industry in the United States has become increasingly concentrated within the past decade, and so it is not surprising that the possibility of non-competitive performance in slaughter cattle and wholesale beef markets is a matter of growing concern.¹ In recent papers (1979, 1982), Ap-

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¹ Connor et al. (1985, p. 75) report that the four firm concentration ratio in beef slaughtering had reached 45% by early 1982, roughly double the 1977 value. The primary concern seems to be the possibility of abusive exercises of monopsony power (Multop and Helmuth, 1980; Ward, 1982; Quail et al., 1985; and Azzam et al., 1986), but the issue of monopoly power has also been addressed (Ball and Chambers, 1982; Parker and Connor, 1980).

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pelbaum presents a technique for estimating the degree of *monopolistic* performance in a market. In the next section, the theoretical framework of that technique is summarized and adapted to the assessment of *monopolistic* and *monopsonistic* performance. An application of the adapted technique to data from the U.S. beef packing industry enables tests of the competitiveness of the industry's input and output markets. Briefly, the results confirm the presence of small price distortions due to monopoly/monopsony power but reveal no apparent tendency, in recent years, toward less competitive performance.

The Model

Let the industry be comprised of N firms (indexed $j = 1, 2, \dots, N$) producing a homogeneous output. In view of the intended application, assume that the production technology is characterized by fixed proportions of output (dressed beef carcasses) and a single material input (live cattle).² With appropriately chosen dimensions, the quantities of the material input and output can then be represented by the same variable for both the j^{th} firm (Q^j) and the industry ($Q = \sum_{j=1}^N Q^j$). Additional inputs are employed in variable proportions in the conversion of the material input to output. Denote the j^{th} firm's quantity of the i^{th} non-material input by x_i^j . For a fixed level of output, each firm will minimize the costs of non-material inputs. Assuming that these inputs are purchased in competitive factor markets, Shephard's Lemma applies and the non-material factor demands for the j^{th} firm are

$$x_i^j = \partial C^j(Q^j, w) / \partial w_i \text{ for all } i \tag{1}$$

where $C^j(\cdot, \cdot)$ is the j^{th} firm's non-material input cost function, w_i is the price of the i^{th} non-material input, and w is a vector of the w_i 's.

Firms are not necessarily price takers in the material input and output markets, however. In general, each expects that a change in its own output will affect market quantity and price to some degree. Let market price and quantities be related via industry demand and supply functions

$$Q = H(p, Z_1) \tag{2}$$

$$Q = F(w_M, Z_2) \tag{3}$$

where p is the price of output, w_M is the price of the material input, and Z_1 and Z_2 are vectors of exogenous

² This assumption seems entirely appropriate since U.S. annual average dressing yields for cattle (carcass weight per 100 lbs. of live animal) have varied by less than 8% in a gradual upward trend over the past 30 years. Even this modest variation is due mainly to changes in the composition of the slaughter rather than variation in dressing yields for specific grades and size classes.

variables. The problem for the j^{th} firm is to choose Q^j to maximize

$$pQ^j - w_M Q^j - C^j(Q^j, w)$$

subject to (2) and (3). The first order necessary condition is

$$p(1 + \theta^j/\eta) = w_M(1 + \theta^j/\epsilon) + \partial C^j/\partial Q^j \tag{4}$$

where $\eta = (\partial H/\partial p)p/Q$, the elasticity of market demand;

$\epsilon = (\partial F/\partial w_M)w_M/Q$, the elasticity of material input supply; and

$\theta^j = (\partial Q/\partial Q^j)Q^j/Q$, the j^{th} firm's conjectural elasticity.

That is, θ^j is the j^{th} firm's perceived rate of change of market output (material input) with respect to own output (material input), expressed as an elasticity. Price taking firms expect that changes in their own output levels will leave price and, hence, market quantity unchanged; consequently, $\theta^j = 0$ in this case. In a pure monopoly, $Q \equiv Q^j$ and so $\theta^j = 1$. In general, firms that wield market power anticipate a fall in price (increase in market quantity) in response to an increase in own output. For such firms, $\theta^j > 0$. A test of $\theta^j = 0$ can thus be interpreted as a test of competitive behavior.

Two useful indices of market power can be derived from equation (4), which asserts equality between the firm's perceived marginal revenue and perceived marginal cost. As is well known, Lerner's index, the difference between price and marginal cost as a proportion of price, measures the relative monopoly price distortion. Denoting the j^{th} firm's Lerner's index by L^j , equation (4) can be manipulated to yield

$$L^j = -\theta^j/\eta. \tag{5}$$

When equation (4) is rearranged as

$$w_M(1 + \theta^j/\epsilon) = p(1 + \theta^j/\eta) - \partial C^j/\partial Q^j, \tag{6}$$

it expresses equality between the marginal factor cost of the material input and its marginal net revenue product (*MNRP*), the marginal revenue product net of the marginal cost of non-material inputs. Since *MNRP* and the factor price would be equal if the market were competitive, the difference between *MNRP* and w_M as a proportion of the latter is an index of the relative monopsony price distortion. Denoting this index for the j^{th} firm by M^j , equation (6) can be rearranged to yield

$$M^j = \theta^j/\epsilon. \tag{7}$$

Note that both of the proposed indices measure monopoly/monopsony power directly in terms of price distortions, rather than indirectly, in terms of profit rates or concentration.

The usual difficulties of obtaining firm-specific data require that any econometric implementation of the

model be carried out using industry data. Thus, certain aggregation conditions must be maintained in order that equations (1) and (4) have meaningful, industry-wide counterparts. Assume that the firms' non-material input cost functions are given by

$$C^j(Q^j, w) = Q^j C(w) + G^j(w) \text{ for } j = 1, 2, \dots, N. \quad (8)$$

Marginal processing costs are thus taken to be constant at a value common to all firms.³ As Appelbaum (1982) points out, this is the usual assumption required for aggregation across firms. Using equations (1), the industry demands for non-material inputs are

$$x_i \equiv \sum_{j=1}^N x_i^j = Q \partial C(w) / \partial w_i + \sum_{j=1}^N \partial G^j(w) / \partial w_i \text{ for all } i. \quad (9)$$

Since $\partial C^j / \partial Q^j = C(w)$ for all firms, equation (4) implies that, in equilibrium, all firms will operate with the same value of θ^j .⁴ Denoting this common value by θ , equation (4) can be rewritten in terms of industry variables and parameters alone as

$$p(1 + \theta/\eta) = w_M(1 + \theta/\epsilon) + C(w). \quad (10)$$

Estimation and Empirical Results

To estimate the model, functional forms must be chosen for equations (2), (3) and (8), the components of the vectors Z_1 and Z_2 must be identified, and a parameterization for the conjectural elasticity, θ , must be introduced. Take the industry non-material input cost function to be of the generalized Leontief form.⁵ Specifically, let

$$C(Q, w) \equiv \sum_{j=1}^N C^j(Q^j, w) = Q \sum_i \sum_k b_{ik} (w_i w_k)^{1/2} + \sum_i b_i w_i$$

³ Since firms possess monopsony power in the market for the single material input, the marginal factor cost of this input does vary across firms as firms' conjectural elasticities vary.

⁴ This does not mean that all firms have the same conjectural elasticity functions; merely that, in equilibrium, all will choose output levels at which θ values are the same. The model would have implications about market structure if assumptions about the specific nature of firms' conjectures were added. For example, with Cournot conjectures, $\theta^j = Q^j/Q$ and equilibrium implies equal market shares.

⁵ See Diewert (1974) for a discussion of the generalized Leontief cost function and its properties. The sample period witnessed the advent of "boxed beef" as an important alternative to the less highly processed carcass beef product. Since degrees of freedom were quite scarce, no allowance was made in estimation for changes in the structure of the cost function due to such technological changes.

where

$$b_{ik} = b_{ki} \text{ for all } i \text{ and } k, \\ C(w) = \sum_i \sum_k b_{ik} (w_i w_k)^{1/2},$$

and

$$\sum_{j=1}^N G^j(w) = \sum_i b_i w_i.$$

With the non-material inputs taken to be labor ($i = L$) and capital ($i = K$), for example, equations (9) and (10) become

$$x_K = (b_{KK} + b_{LK}(w_L/w_K)^{1/2})Q + b_K \quad (11)$$

$$x_L = (b_{LL} + b_{LK}(w_K/w_L)^{1/2})Q + b_L \quad (12)$$

$$p(1 + \theta/\eta) = w_M(1 + \theta/\epsilon) + (b_{LL}w_L + 2b_{LK}(w_Lw_K)^{1/2} + b_{KK}w_K). \quad (13)$$

For the demand and supply relations, equations (2) and (3), assume the following functional forms

$$\begin{aligned} (\text{demand}) \ln Q &= a + \eta \ln(p/S_1) + \gamma_1 \ln(p_h/S_1) \\ &\quad + \gamma_2 \ln(p_c/S_1) + \gamma_3 \ln(Y/S_1) \\ &\quad + \gamma_4 \ln(POP) \end{aligned} \quad (14)$$

$$\begin{aligned} (\text{supply}) \ln Q &= b + \epsilon \ln(w_M/S_2) + \delta_1 \ln(p_f/S_2) \\ &\quad + \delta_2 \ln(C_s) \end{aligned} \quad (15)$$

where

- S_1 = consumer price index
- p_h = wholesale price of pork
- p_c = wholesale price of chicken
- Y = per capita nominal income
- POP = population
- S_2 = farm output price index
- p_f = price of feed corn, and
- C_s = stock of cattle on farms.⁶

Provision of a formal model of firms' conjectures is beyond the scope of this paper so, as in Appelbaum (1982), θ is simply modeled as a general function of exogenous variables to allow equilibrium conjectures to vary with market conditions. Hence, define

$$\theta_t = \theta_1 + \theta_2 w_L + \theta_3 w_K + \theta_4 t \quad (16)$$

where t is a time trend variable included as a proxy for omitted economic variables, and $\theta_1, \theta_2, \theta_3,$ and θ_4 are unknown parameters.⁷ Conjectural elasticity, and its

⁶ Details of variable definitions are contained in an appendix available from the author upon request.

⁷ Concentration is likely to influence equilibrium conjectures. Annual data on concentration in beef packing are unavailable, however.

TABLE 1.—RESULTS OF FULL INFORMATION MAXIMUM LIKELIHOOD ESTIMATION, ANNUAL DATA, SAMPLE = 1951–83

	Estimate	Asymptotic Standard Error		Estimate	Asymptotic Standard Error
b_{LL}	0.00278	(0.00034)	ϵ	1.6886	(0.1453)
b_{LK}	0.00020	(0.00013)	δ_1	-0.0485	(0.1575)
b_{KK}	0.2026	(0.1911)	δ_2	2.5313	(0.2720)
b_L	101.45	(133.35)	θ_1	0.0369	(0.0062)
a	13.769	(0.183)	θ_2	-0.0019	(0.0005)
η	-0.5273	(0.0642)	θ_3	0.0073	(0.0028)
γ_1	0.1789	(0.0528)	θ_4	-0.0014	(0.0010)
γ_2	-0.0690	(0.0428)	ρ_1^a	1.0129	(0.0166)
γ_3	1.3409	(0.2141)	ρ_2	0.2126	(0.1443)
γ_4	-0.6996	(0.0884)	ρ_3	0.7026	(0.1951)
b	-26.763	(3.746)	ρ_4	0.1416	(0.1467)
Conventional R^2 values ^b for equation:					
(12)				0.867	
(13)				0.992	
(14)				0.988	
(15)				0.746	
Log of likelihood function				-225.80	

^a $\rho_1, \rho_2, \rho_3,$ and ρ_4 are first order autoregressive parameters for the disturbances of equations (12), (13), (14), and (15), respectively. The point estimate of ρ_1 is greater than one. The marginal significance level for a test of $\rho_1 > 1$ is well above conventional levels, however.

^bThe conventional R^2 values are the proportions of the variation in an endogenous variable (p for the profit maximization condition, $\ln Q$ for demand and supply, and x_L for labor demand) which are explained by each equation's series of one step ahead forecasts based on FIML estimates of the model's parameters.

TABLE 2.—ESTIMATES OF CONJECTURAL ELASTICITIES AND MONOPOLY / MONOPSONY PRICE DISTORTIONS FOR SELECTED YEARS

Year	Conjectural Elasticity, θ		Monopoly Price Distortion, $L = -\theta/\eta$		Monopsony Price Distortion $M = \theta/\epsilon$	
1951	.0417	(.0061)	.0791	(.0125)	.0247	(.0044)
1955	.0360	(.0063)	.0683	(.0132)	.0213	(.0042)
1960	.0286	(.0074)	.0542	(.0155)	.0169	(.0046)
1965	.0222	(.0079)	.0420	(.0163)	.0131	(.0047)
1970	.0149	(.0103)	.0282	(.0206)	.0088	(.0061)
1975	.0176	(.0083)	.0333	(.0168)	.0104	(.0049)
1977	.0217	(.0063)	.0412	(.0131)	.0129	(.0038)
1979	.0179	(.0093)	.0339	(.0188)	.0106	(.0055)
1980	.0178	(.0102)	.0337	(.0205)	.0105	(.0060)
1981	.0141	(.0126)	.0268	(.0250)	.0084	(.0075)
1982	.0182	(.0095)	.0345	(.0191)	.0108	(.0056)
1983	.0190	(.0074)	.0360	(.0151)	.0112	(.0044)

Note: Parentheses contain asymptotic standard errors.

implications about market power, are the main focus of this research but when (16) is substituted into equation (13), the θ_i 's are identified only if information on η and ϵ is available. In addition, the impact of the choice of a specific form for the cost function will be reduced if (13) is estimated subject to the theoretical restrictions on cost parameters embodied in equations (11) and (12). These considerations suggest joint estimation of equations (11) through (15). Unfortunately, construction of a reliable capital input series was not possible, so equation (11) could not be used.

The system of equations (12) through (15), with θ_i as given in (16), was estimated in quasi-first difference

form by full information maximum likelihood (FIML) using annual data from the U.S. beef packing industry for the years 1951 through 1983.⁸ The results are reported in table 1.

The generalized Leontief cost function is linearly homogeneous by construction. Concavity is guaranteed

⁸ Specifically, the equations were augmented with additive error terms assumed to follow first-order autoregressive patterns, and then transformed to versions with nonautocorrelated disturbances by quasi-first differencing. The AR(1) parameters and the structural parameters of the model were estimated jointly. Amemiya (1977) establishes the asymptotic distribution for the FIML estimator.

by a positive sign for b_{LK} . Positive values for b_{LL} , b_{KK} , and b_L , as well as b_{LK} , guarantee that the cost function is positive and increasing in each factor price for all points in input price space. Thus, the estimated cost function is well behaved.

Estimates of γ_1 and γ_3 suggest that beef is a normal good for which pork is a substitute. The significantly negative estimate of γ_4 is anomalous, however. The population variable may be serving as a proxy for a time trend and capturing the effect of recent changes in tastes that have shifted consumption patterns from red meat to alternative sources of protein. The estimate of δ_2 confirms theory suggesting that the supply of slaughter cattle is positively related to the stock of cattle on farms.⁹

The estimates of the parameters of equation (16) and their implications about conjectural elasticities and market power are of primary interest. Table 2 displays estimates and standard errors for conjectural elasticities and the indices of monopoly (equation (5)) and monopsony (equation (7)) power for several of the years in the sample. The estimates of θ are significantly greater than zero at the 1% level in 20, and at the 5% level in 28 of the 33 years. Thus, there is clear evidence that the assumption of price-taking behavior is inappropriate for the beef packing industry.¹⁰ The attendant monopoly/monopsony price distortions tend to be relatively modest, however, as the estimated magnitudes of L and M indicate. In the later years of the sample, the output and input market relative price distortions are about 3% and 1%, respectively. Moreover, the recent decline in structural competitiveness (that is, the post-1977 increase in industry concentration) has not increased the size of these distortions: The values of L and M have been relatively stable since 1970.¹¹

⁹ Surprisingly, chicken is not revealed to be an important substitute for beef; the estimate of γ_2 is negative though insignificant. The fact that the estimate of δ_1 is insignificant is not surprising, however, in view of the ambiguity of the relationship between cattle supply and feed price. A high price of feed, if anticipated, could have produced past curtailments of breeding activity and be associated with low current supply. If unanticipated, it could lead to liquidation of current stocks and high current supply.

¹⁰ The magnitudes of conjectural elasticities estimated in this study are roughly comparable to those Appelbaum (1982) found for the rubber and textile industries. Those estimates generally were not statistically significant, however, and led to the conclusion that the industries are characterized by competitive behavior.

¹¹ The work of Bradburd and Over (1982) suggests one possible means of reconciling increasing concentration with no deterioration in performance. Their evidence indicates that the "integrative" concentration level, the level at which cooperative behavior becomes rational, can be quite high ($CR4 \approx 68\%$).

Summary

Recent increases in concentration in the U.S. beef packing industry have raised the suspicion of non-competitive performance. This paper investigates that possibility by adapting and applying a technique for estimating performance based indices of input and output market power. The technique produces estimates of monopoly/monopsony price distortions that generally are statistically significant but of quite small magnitude. Moreover, they suggest that there has been no appreciable worsening of the markets' performance during the recent period of increasing concentration.

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