Horizontal Consolidation in the U.S. Food Processing Industry: Boon or Bane?

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Abstract

A bilateral oligopoly model is used to measure the effect of increased concentration on industry market power and cost efficiency. Consistent with previous studies, we find that cost efficiency gains dominate potential market power effects from increased concentration in the U.S. wholesale beef industry.

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Background

As agricultural food processing and retailing industries become increasingly concentrated, there have been numerous studies examining the impact of changes in market structure on social welfare (Azzam; Kinnucan). An issue of increasing concern is whether industry efficiency gains dominate market power effects resulting from an increase in industry concentration.

Most industrial organization literature suggests that mergers' efficiency gain offsets consumers' potential welfare loss (Azzam; Azzam and Schroeter; Sexton). More recently, however, Lopez et al. found that market power effects dominates cost efficiency effects in most industries, and that further increase in concentration would "increase output price in nearly every case."

Previous studies have some limitations. First, the wholesale market is assumed to possess oligopsony power in some studies (Azzam and Schroeter; Azzam), and oligopoly in other studies (Lopez et al.). Yet, the US beef industry is very concentrated by most economic standards (Ward). Allowing for market power in procuring farm inputs (selling final output) while ignoring potential market power in selling final output (procuring farm inputs) is likely to understate market power effects. Second, market conduct parameters estimated using New Empirical Industrial Organization models seem sensitive to demand specification. Hennessey argues that, at least theoretically, there are demand schedules, with well-behaved properties, such that welfare-reducing merges might appear privately and socially attractive even if there are no efficiency gains. These restrictive assumptions may have dictated previous results.

This study follows Azzam, and Lopez at al. by also separating market power effects from cost efficiency resulting from an increase in industry concentration. However, unlike these authors, we allow for oligopsony power in the cattle procurement market and oligopoly power in the beef retail market. Second, we use several alternative specifications for retail output demand to provide a sensitivity analysis on parameter estimates. Industry tradeoffs caused by increased concentration in the beef processing industry are estimated assuming profit-maximizing behavior of three major players, retailer, processor, and raw material producer.

The objective of this study is twofold. First, the effects of increase of concentration on industry costs and market power are separated out in a bilateral oligopoly framework. Second, alternative demand specifications are used to provide a sensitivity test on parameter estimates.

The remainder of the paper is organized as following. The next section introduces a bilateral oligopoly model. Empirical procedures for the case of the U.S. beef industry are presented in section 2. Section 3 reports the results, and section 4 presents concluding remarks.

I. The Model

Consider an industry where processors compete imperfectly in procuring farm inputs from a competitive farm sector. Processors sell their output to retailers competing imperfectly in selling final product to consumers. Both processing and retailing sectors are assumed to be concentrated, and the interaction between processors and retailers is a characterized by a non-domination imperfect competition. In this bilateral oligopoly setting (Blair et al., Machlup and Taber), total industry output is similar to the output that would result from joint profit maximization between processors and retailers (Schneider). In view of the intended application, this industry is modeled as a single "processing industry" which competes imperfectly in procuring farm input and in selling final output consumers.

Assume there are *n* processors converting farm inputs into processed output using fixed proportions technology. The production technology also uses non-farm inputs, which are purchased in competitive markets.

Considering *n* identical processors producing homogeneous output, i.e., $Y = Y^p = Y^f = ny$, a representative processors' profit maximization problem is

(1) $$\max_{y^p} \ \pi^p = [P^p(Y^p) - P^f(Y^f)]y^p + C(y^p, \mathbf{v})$$

where P^p is the output price, P^f is the farm input price, $C(.)$ is the processor's cost function. The first order condition for profit maximizing is

$$\frac{\partial \pi}{\partial y^p} = P^p + (\frac{dP(Y^p)}{dY^p}\frac{\partial Y^p}{\partial y^p} - \frac{dY^f}{dY^f}\frac{\partial Y^f}{\partial y^f})y^p - P^f - c(y^p, \mathbf{v}) = 0.$$

Rearranging the first order condition and re-writing it in elasticity form yields

(2) $$P^p + \frac{y^p}{\varepsilon_d^r Y^p}(1+\phi_j) = P^f + P^f\frac{y^f}{\varepsilon_s^f Y^f}(1+\theta_j) - c(y^p, \mathbf{v}),$$

where $\varepsilon_d^r = (\partial Y^r / \partial P^r)(1/Y^r)$ and $\varepsilon_s^f = (dY^f / dP^f)(P^f / Y^f)$ are the semi-elasticity of retail demand and elasticity of farm supply, respectively, $\phi_i = d\sum_{i \neq j}^n y_j^p / dy_i^p$ is the *i*th firm's conjecture about its rivals' response to a change in its sales of retail product, and $\theta_i = d\sum_{i \neq j}^n y_j^f / dy_i^f$ is the *i*th firm's conjecture about its rival response to a change in its purchase of farm input. Because of the assumption of fixed proportion technology in converting farm inputs into processed product, $\phi_i = \theta_i$.

Following Azzam, and Lopez et al., the *i*th firm's cost function is assumed to take the generalized Leontief form:

$$(3) \qquad C(y^p, \mathbf{v}) = y^p \sum_i \sum_j \alpha_{ij} (v_i v_j)^{1/2} + y^p t \sum_i \lambda_i v_i + (y^p)^2 + \sum_j \beta_i v_i \ ,$$

where α_{ij}, λ_i, and β_i are parameters. Replacing $c(y^p, \mathbf{v})$ in expression (2) by $\partial C(y^p, \mathbf{v})/\partial y^p$ obtained by differencing expression (3), and multiplying (2) by each firm's market share (y_i/Y), and summing across n firms in the industry, and factoring out P^p and P^f yields:

$$(4) \qquad P^p = -\frac{H}{\varepsilon_d^r}(1+\Phi)] + P^f [1 + \frac{H}{\varepsilon_s^f}(1+\Theta)] + \sum_i \sum_j \alpha_{ij} (v_i v_j)^{1/2} + t \sum_i \lambda_i v_i + 2HY \sum_j \beta_i v_i \ ,$$

where $\Phi = \sum_i (y_i^p)^2 \phi_i / \sum_i (y_i^p)^2$ is the weighed conjectural variation in the output industry, $\Theta = \sum_i (y_i^f)^2 \theta_i / \sum_i (y_i^f)^2$ is the weighed conjectural variation in the input industry, and firms $H = \sum_i (y_i^P / Y)^2$ is the Herfindahl index.

If processors are assumed to compete perfectly in selling farm input (i.e. Φ =-1), then equation (4) is similar to Azzam's equation (5). If processors are assumed to compete perfectly in procuring farm input (i.e. Θ = -1), then equation (4) is similar to Lopez et al. equation (5). Notice that if firms compete Cournot in selling final product and/or in procuring farm input then Φ = 0 and/or Θ = 0, respectively.

Using Shephard's lemma, industry non-farm input demand equations are

$$(5) \qquad \frac{X_r}{Y} = \sum_i \sum_j \alpha_{ij} (v_i v_j)^{1/2} + t\lambda_i + HY\beta_i$$

As in Azzam, and Lopez et al., market power and cost efficiency effects from increasing industry concentration are given by

(6) $$\frac{\partial P^p}{\partial H} = -\frac{(1+\Phi)}{\varepsilon_d^r} + \frac{(1+\Phi)}{\varepsilon_s^f} + 2Y\sum_j \beta_i v_i$$

where the first right hand side is the oligopoly power effect on output price, and the second term is the scale efficiency effect.

II. Empirical procedures

The empirical application uses annual data for the wholesale beef industry, ranging from 1970 to 1996. The data were compiled from several sources. Input quantities and prices are from the National Bureau of Economic Research database (NBER) of Bartelsman et al. on U.S. Manufacturing data. The NBER data are 4-digit SIC. The prices of capital and materials are represented by the NBER's price deflator for capital and materials respectively. Wage per worker-hour are computed by dividing NBER's total payroll by the total number of production workers in the industry. The total supply of commercial beef and retail price of beef, the inventory of beef cows, and the net –farm value of cattle were compiled by the Economic Research Service, United States Department of Agriculture. Productivity of capital services and materials are 2-digit SIC data for the Food and Kindred Products from the Bureau of Labor Statistics (BLS). Consumer price index and price index for farm output data are also from the BLS. Data on 4-firm concentration ration were compiled from several GIPSA annual reports.

Empirical application necessitates specification of farm-input supply and retail output demand schedules. Farm input supply and retail output demand are represented by respectively,

$$(7) \qquad \ln Y = s_0 + \varepsilon_s^f \ln(p_{-3}^f) + s_1 t + s_2 \ln(p_c) + s_3 \ln(p_d)$$

and,

$$(8) \qquad LnY = \delta_0 + \varepsilon_d^r p + \delta_1 t + \delta_2 p_p + \delta_3 I$$

where p_{-3}^f is a lag-three real farm value of cattle , p_c is the real price of calves, p_d is the real price of diesel, p is the real price of beef, p_p is the real price of pork, I is the disposable income and t is a time trend variable. The base year for all price variables is 1987.

A system of equations 4, 5, 7 and 8 was estimated jointly by nonlinear three-stage least squares (N3SLS). Specifically, the estimating model consists of six equations: the pricing equation, the retail demand equation, the cattle supply equation and input demand equations for labor, capital and packing materials.

III. Empirical Results

The results are reported in table 1. Positive values of α_{ij} (when $i = j$ and when $i \neq j$) suggest that packers cost function is concave and well behaved[1]. Own price elasticities for output demand and farm supply of cattle elasticities have the expected size and signs and are significant at the one and six percent levels of statistical significance[2],

[1] Homogeneity and symmetry are guaranteed by construction.
[2] The elasticity of supply is calculated using a three-period lagged farm cattle price.

Table 1. N3SLQ Parameter Estimates

Parameter	Estimate	Std. Error	Parameter	Estimate	Std. Error
Φ	-1.256	0.134	β_L	-0.001	0.003
ε_d^r	-0.318	0.030	β_K	-0.030	0.006
ε_s^f	0.141	0.080	β_M	0.053	0.013
α_{LL}	0.045	0.032	δ_0	4.479	0.201
α_{KK}	0.597	0.221	δ_1	0.0002	0.003
α_{MM}	1.227	0.292	δ_2	0.013	0.031
α_{LK}	0.341	0.108	δ_3	-0.00004	0.00001
α_{LM}	0.151	0.129	s_0	3.470	0.199
α_{MK}	-0.611	0.192	s_1	-0.004	0.005
λ_L	-0.012	0.003	s_2	-0.182	0.035
λ_K	0.034	0.011	s_3	-0.098	0.043
λ_M	-0.033	0.014			

respectively. The sign of the income elasticity coefficient, δ_3, is anomalous. It suggests that beef is an inferior good.

The estimate of the conjectural elasticity, Φ, is negative and statistically significant at the 1% level of significance. Thus, the assumption of packers price taking behavior ($\Phi = -1$) when procuring cattle and when selling processed beef is rejected. This result is consistent with previous studies that found that packers compete imperfectly when procuring farm inputs and when selling processed output.

The estimate of cost-elasticity, given by MC/AC suggests that the beef packing industry has significant economies of size. Thus, consistent with previous results, we find that consolidation in the beef packing industry could be efficiency driven. Notice, however, that the size of the cost elasticity estimate (0.75) is relatively smaller than the values of 0.95 reported by Lopez et al.

The basic hypothesis of this study is that an increase in market concentration generates losses in both cattle procurement markets and beef retail markets. Oligopoly and oligopsony power effects due to increase in concentration are statistically significant at the five percent level. Notice that the estimate of market power affects in the cattle procurement market, 1.8, is a double (in absolute value) of the estimate for market power effects in the output market, 0.9. Thus, farmers seem to suffer bigger loss when concentration in the beef processing industry increases. Notice also, that the estimate of the "total" market power effect, 2.7, is greater than the estimate of 0.2 and 2.4 reported by Azzam, and by Lopez et al., respectively. Azzam assumed perfect competition in the output markets, and Lopez et al. assumed that packers compete perfectly when procuring cattle inputs. Hence, estimates of market power in previous studies seem underestimated.

The estimate of cost efficiency gain from increased concentration is -3.76. The net price effect is -1.09. Thus, our bilateral monopoly model suggests that increase consolidation in the beef packing industry results in significant decrease in beef prices at the retail level.

Concluding Remarks

Most industrial organization literature suggests that mergers' efficiency gain offsets consumers' potential welfare loss. More recently, however, Lopez et al. found that market power effects dominate cost efficiency effects in most industries.

This study extended the work of Azzam, and Lopez et al. by measuring the effect of increased concentration on industry market power and cost efficiency, using a bilateral oligopoly model. The main finding is that cost efficiency gains dominate market power effects from increase in industry concentration. This result is consistent with previous finding that consolidation in the U.S. beef industry is efficiency driven.

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