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Assessing Oligopoly and Oligopsony Power in the U.S. Catfish Industry

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This paper addresses the issue of competition in the U.S. catfish industry. To this end, a conjectural variation oligopolistic model was developed. The model was estimated econometrically using the Generalized Method of Moments (GMM) procedure. Chi-square analysis implied that catfish processors do not exert market power over farmers or over consumers. The conjectural elasticity was estimated to be 0.073, the oligopoly power index 0.28, and the oligopsony power index 0.68, and none of these values were statistically significant. The results support competitive behavior of the catfish processing sector.

Key Words: competition, conjectural variation model, U.S. catfish industry

The catfish industry has emerged as one of the largest components of the U.S. aquacultural sector, accounting for over 50% of U.S. aquaculture production. Production of processed catfish has risen considerably over the last decade, from 198.9 million kg in 1994 to 285.3 million kg in 2004 (USDA/National Agricultural Statistics Service, 2005). The major catfish processing plants are primarily located in the southern states of Alabama, Arkansas, Louisiana, and Mississippi.

Previous studies have suggested that the structure of the catfish processing sector is highly concentrated. Dillard (1995) estimated a four-firm concentration ratio of 60%–70%. Concentration can lessen competition because concentrated processors may be able to increase prices charged to consumers and, at the same time, depress prices paid to farmers. Concerns over concentration in the catfish industry and possible anti-competitive effects have been discussed in previous studies (Kinnucan and Sullivan, 1986; Kouka, 1995). Market power at the processor level could have adverse ramifications for the catfish industry in that it could lead to market inefficiencies and a reduction in welfare of catfish farmers.

In aquaculture, several studies have tested for market power related to the salmon market. Steen and Salvanes (1999), using a dynamic error correction model, showed the French market for fresh salmon to be competitive in the long run and noncompetitive in the short run. Jaffry, Fofana, and Murray (2003) adopted Steen and Salvanes'

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approach and found that the salmon retail market in the United Kingdom was competitive in both the short and long run.

This paper uses new empirical industrial organization (NEIO) methodology to assess the degree of competitiveness in the U.S. catfish industry. In a seminal article, Bresnahan (1982) introduced an empirical method for inferring the degree of market power in a given industry. Since then, numerous studies have adapted Bresnahan's approach to test the degree of market power in different markets (e.g., Appelbaum, 1982; Schroeter, 1988; Sexton, 1990).

The analysis of market power in the catfish industry has been the subject of various studies. Kinnucan and Sullivan (1986) used a theoretical model to estimate the potential economic effects of market power imbalance on catfish producers in west Alabama. Their analysis was based on the assumption that the development of monopsony in west Alabama would lead to market imbalance. The paper did not explicitly test for market power, but estimated a 12%–35% potential reduction in prices received by Alabama catfish producers as a result of a monopsonistic processing sector. Kinnucan and Sullivan's methodology was based on a simple economic model for monopsony price as a function of competitive price and supply elasticity. To compute the monopsony price, they used the 1983 average price received by Alabama farmers as a proxy for competitive price and an estimate of supply elasticity.

Kouka (1995) developed an empirical model to examine the degree of oligopoly power in the U.S. catfish industry. In Kouka's model, both the production and the processing sectors were taken as an integrated component. The estimate of the oligopoly power index revealed that catfish processors exerted some degree of market power.

Hudson (1998) adapted Holloway's (1991) approach of farm-retail price spread to test the degree of competition in the catfish industry. Wiese and Quagrainie (2004) analyzed the level of oligopsony power in the live catfish market by estimating a market power index. Using a simultaneous equation model of the supply and perceived demand, their findings suggest that the catfish processing sector is competitive.

The current paper differs from previous studies in two major ways. First, apart from Kouka's (1995) paper, prior studies focused on the supply side (oligopsony power). Here, we follow Schroeter's (1988) methodology to explicitly account for both oligopoly and oligopsony power. In the consumer demand side, we examine whether catfish processors exert market power over consumers (oligopoly power), and in the live catfish supply side, we investigate whether catfish processors exert market power over farmers (oligopsony power).

Second, although Kouka (1995) examined whether catfish processors exerted market power over consumers (oligopoly power), the author treated the processing sector and the production of live catfish as an integrated entity. This is a strong assumption because in reality the catfish processing sector is composed of independent processing plants that purchase live catfish from private catfish farms; only a very limited number of processors are vertically integrated. The novelty of our analysis is that it treats the processing sector as a separate sector from the live catfish production sector.

The remainder of the paper proceeds as follows. The next section derives the model. The following section is devoted to empirical results and discussion. Concluding remarks are provided in the final section.

The Model

The model consists of a set of N catfish processors producing a homogeneous output. Each processor has a fixed proportion technology where one unit of its material input (live fish) becomes one unit of its final output (processed fish). Catfish processors are not necessarily price-takers in both material-input and output markets. The profit of the ith processor can be written as:

$$\pi^i = \big(P_p(Q) - P_f(Q)\big)q_i - C_i(q_i, \mathbf{v}), \tag{1}$$

where P_p is the price received by catfish processors, P_f is the price paid to catfish farmers, q_i is the quantity processed by the ith processor,

$$Q = \sum_{i=1}^{N} q_i$$

is the industry's total processed catfish, C_i is the processing cost, and $\mathbf{v}$ is a vector of input prices.

Totally differentiating (1) with respect to q_i yields the first-order condition:

$$P_p + \frac{dP_p}{dQ}\frac{dQ}{dq_i} = P_f + \frac{dP_f}{dQ}\frac{dQ}{dq_i}q_i + \frac{dC_i}{dq_i}. \tag{2}$$

Converting (2) into elasticities and rearranging yields the supply relation:

$$P_p\left(1 + \frac{\theta_i}{\varepsilon}\right) = P_f\left(1 + \frac{\theta_i}{\eta}\right) + mpc_i, \tag{3}$$

where

$$\varepsilon = \frac{dQ}{dP_p}\frac{P_p}{Q}$$

is the elasticity of market demand,

$$\eta = \frac{dQ}{dP_f}\frac{P_f}{Q}$$

is the price elasticity of material-input supply, mpc_i is the marginal processing cost, and

$$\theta_i = \frac{dQ}{dq_i}\frac{q_i}{Q}$$

is the *i*th processor's conjectural variation elasticity. The processor's conjectural variation elasticity, θ_i, can be defined as the percentage change in output (material input) market due to a percentage change in the *i*th processor's output (material input).

Since data at the processor level are not available, data at the industry level are used instead. The use of industry data requires, however, some further assumptions to allow for aggregation across processors. To this end, processors are assumed to have the same processing cost. Letting $mpc_i = mpc$ for all i, and multiplying (3) by each processor's market share (q_i/Q) and summing over the number of processors, yields the industry supply relation:

$$(4) \qquad P_p\left(1 + \frac{\Theta}{\varepsilon}\right) = P_f\left(1 + \frac{\Theta}{\eta}\right) + mpc,$$

where

$$\Theta = \sum_i \left(\frac{q_i\theta_i}{Q}\right)$$

is the industry conjectural variation elasticity. Hence, if $\Theta = 0$, then processors are price-takers in both output and material input markets. Pure monopoly/monopsony occurs when $\Theta = 1$. Values between 0 and 1 indicate intermediate levels of market power. The oligopoly power index, $-(\Theta/\varepsilon)$, captures the gap between output price and marginal cost. Thus, the higher (lower) the conjectural variation elasticity (the demand elasticity), the higher the oligopoly power. The oligopsony power index, Θ/η, captures the gap between input price and the value of the marginal product. Hence, the higher (lower) the conjectural variation elasticity (the supply elasticity), the higher the oligopsony power.

Assuming the processing cost takes the generalized Leontief form (Diewert, 1974),

$$(5) \qquad C(q_i, \mathbf{v}) = q_i \sum_i \sum_k \gamma_{ik}(v_i v_k)^{1/2} + \sum_i b_i v_i,$$

such that $\gamma_{ik} = \gamma_{ki}$. Differentiating (5) with respect to q_i yields the marginal processing cost:

$$(6) \qquad mpc = \sum_i \sum_k \gamma_{ik}(v_i v_k)^{1/2}.$$

Substituting (6) into (4) gives:

$$(7) \qquad P_p\left(1 + \frac{\Theta}{\varepsilon}\right) = P_f\left(1 + \frac{\Theta}{\eta}\right) + \sum_i \sum_k \gamma_{ik}(v_i v_k)^{1/2}.$$

To identify the degree of market power, as captured by Θ, the elasticity of market demand (g) and the price elasticity of material-input supply (η) must be estimated separately. To do so, the market demand function for processed catfish and the supply function for live catfish must be specified. Let the consumer demand for catfish take the following form:

$$(8) \qquad \ln(Q) = \alpha_0 + \underset{-}{g}\ln\left(\frac{P_p}{cpi}\right) + \underset{+}{\alpha_1}\ln\left(\frac{P_{por}}{cpi}\right) + \underset{+}{\alpha_2}\ln\left(\frac{P_{bee}}{cpi}\right) + \underset{+}{\alpha_3}\ln\left(\frac{P_{chi}}{cpi}\right) + \underset{+}{\alpha_4}\ln(gdp) + \underset{+}{\alpha_5}\ln(pop) + \underset{+}{\alpha_6}t,$$

where Q is the quantity of catfish sold by processors; cpi is the consumer price index; gdp is per capita real gross domestic product used as a proxy for income; pop is population; t is a time trend; and P_{por}, P_{bee}, and P_{chi} are the wholesale price of pork, beef, and chicken, respectively. The expected signs are given below the relevant coefficients. A potential substitute for catfish would be tilapia; unfortunately, data on price of tilapia are not available.

In the supply side, catfish production requires three main inputs: feed, fingerlings, and labor. According to Posadas (2000), feed and fingerlings constitute 42.9% and 17% of total cost, respectively. Hence, using a double-log functional form, the supply for live catfish can be written as:

$$(9) \qquad \ln(Q) = \beta_0 + \underset{+}{\eta}\ln\left(\frac{P_f}{ipf}\right) + \underset{-}{\beta_1}\ln\left(\frac{P_{fee}}{ipf}\right) + \underset{-}{\beta_2}\ln\left(\frac{P_{fin}}{ipf}\right) + \underset{-}{\beta_3}\ln\left(\frac{w}{ipf}\right),$$

where ipf is the index of prices received by farmers, P_f is the price paid to catfish farmers, P_{fee} is the price of feed, P_{fin} is the price of fingerlings, and w is wage. The expected signs are given below the relevant coefficients.

For empirical application, it is assumed that the catfish processing sector uses three inputs: labor (v_L), energy (v_E), and capital (v_K). Since data on the cost of capital are not available, the bank prime loan rate is used as a proxy. If at all possible, the cost function should also include material, but unfortunately, data on this item are not available. The supply relation, as given by (7), becomes:

$$(10) \qquad P_p\left(1 + \frac{\Theta}{g}\right) = P_f\left(1 + \frac{\Theta}{\eta}\right) + \left(\gamma_{LL}v_L + 2\gamma_{LE}(v_L v_E)^{1/2} + 2\gamma_{LK}(v_L v_K)^{1/2} + 2\gamma_{LK}(v_L v_K)^{1/2} + \gamma_{KK}v_K + \gamma_{EE}v_E\right).$$

Empirical Results and Discussion

Annual data from 1987 to 2003 were used to estimate (8), (9), and (10). Data were taken from various sources. Table 1 provides detailed definitions of the variables, along with their sources. The system of equations as given by (8), (9), and (10) was

Table 1. Definitions of Variables and List of Data Sources

Variable	Definition
P_p	Nominal wholesale price of processed catfish (¢/lb.)
P_{por}	Nominal wholesale price of pork (¢/lb.)
P_{bee}	Nominal wholesale price of beef (¢/lb.)
P_{chi}	Nominal wholesale price of chicken (¢/lb.)
gdp	Per capita real gross domestic product ($)
pop	Population (1,000s)
ipf	Index of prices received by farmers (%)
Q	Quantity of catfish sold by processors (1,000 lbs.)
P_f	Nominal price paid to catfish farmers (¢/lb.)
P_{fee}	Nominal feed price ($/ton)
P_{fin}	Nominal price of fingerlings (¢/lb.)
w	Hired farm workers' nominal average wage ($/hour)
cpi	Consumer price index (%)
v_L	Nominal minimum hourly wage ($/hour)
v_E	Nominal average retail electricity prices, industrial customers (¢/kilowatt hour)
v_K	Bank prime loan rate used as a proxy for the cost of capital (%)

Data on the model's variables were obtained from the following sources:

- Wholesale price of pork, beef, and chicken, and index of prices received by farmers were obtained from various issues of *Livestock and Poultry Situation and Outlook Report* (U.S. Department of Agriculture/Economic Research Service, 1987–2003).
- Per capita real gross domestic product and population were taken from various census publications (U.S. Department of Commerce, Bureau of the Census, 1987–2003).
- Wholesale price of processed catfish, quantity of catfish sold by processors, price paid to catfish farmers, hired farm workers' average wage, and prices of fingerlings were obtained from various issues of *Aquaculture Situation and Outlook Report: Catfish and Trout Production* (U.S. Department of Agriculture/National Agricultural Statistics Service, 1987–2005).
- Average retail electricity prices were taken from various issues of *Monthly Energy Review* (U.S. Department of Energy, Energy Information Administration, 1987–2003).
- Minimum hourly wage and consumer price index were obtained from various issues of *Employment and Earnings* (U.S. Department of Labor, Bureau of Labor Statistics, 1987–2003).
- Feed price was obtained from various publications of the Mississippi Cooperative Extension Service.
- The bank prime loan rates were taken from the Economic Time Series Database (available online at http://www.economagic.com/em-cgi/data.exe/fedbog/prime).

estimated using the Generalized Method of Moments (GMM) procedure with correction for serial correlation and heteroskedasticity. As is well known, GMM requires a weighting matrix. This was estimated based on the robust covariance matrix estimator of Newey and West (1987). The results are summarized in table 2.

According to the table 2 results, the overall fit of the regression appears to be quite good. Of the 20 parameters, 11 are statistically significant. For the demand equation, the own-price elasticity is negative and less than one, suggesting that the demand for catfish is inelastic. Using the indirect translog demand system, Hanson, Hite, and Bosworth (2001) reported own-price elasticities of −0.0371, −1.0106, −1.1473, and −0.8744 for whole fish, fillet, steak, and nugget, respectively. Surprisingly, chicken and beef were found to be complements for catfish rather than substitutes. The income elasticity of demand for catfish is positive, suggesting that catfish is a normal good. This finding is in line with the literature. Hanson, Hite, and Bosworth (2001) reported an income elasticity of 0.9912. The estimate of the population variable is positive—in part reflecting consumers' increasing preference for catfish. This result is in accord with that found by Shreay (2005). In the supply estimation results, the supply elasticity is very low, indicating the supply of live catfish is inelastic. The significant positive estimate of β_3 is anomalous. The remaining parameters have the expected signs and are statistically significant.

The main parameters of interest are the conjectural variation elasticity, oligopoly power, and oligopsony power indices. A test for price-taking behavior amounts to testing the hypothesis that $\Theta = 0$. With a χ^2 statistic of 1.28, the hypothesis cannot be rejected ($\chi^2_{[1, 0.01]} = 6.63$), implying that catfish processors do not exert market power over farmers or over consumers. Moreover, estimates of oligopoly/oligopsony power indices are small and statistically insignificant.

To account for factors that may affect the conduct of firms, the model was reestimated by letting the conjectural variation elasticity (Θ) vary with some exogenous variables. Specifically, as in Appelbaum (1982), we allow the conjectural elasticity to vary with the prices of labor, energy, capital, and a time trend. The conjectural elasticity then becomes:

$$\Theta = \theta_0 + \theta_1 v_E + \theta_2 v_L + \theta_3 v_K + \theta_4 t. \tag{11}$$

Parameter estimates of the conjectural variation elasticity and its estimates for selected years are reported in tables 3 and 4, respectively. The results reveal that the magnitude of the conjectural elasticity is small. Evaluated at the mean of the data, the conjectural elasticity is 0.073, but is not statistically significant (table 4)—giving support to the notion that the catfish processing sector is competitive. These results are consistent with findings reported by some of the earlier studies (Nyankori, 1991; Dillard, 1995; Wiese and Quagrainie, 2004).

The nonexistence of market power in the catfish industry as revealed in this paper can be attributed, in part, to tradeoffs between market power and cost efficiencies due to concentration (Williamson, 1968). Consequently, the magnitude of cost efficiencies most likely outweighs that of market power arising from concentration.

Table 2. Model Estimates and Standard Errors

Item	Parameter	Estimate	Standard Error
Demand Equation:			
Intercept	α_0	!104.8800***	26.212
Elasticity of market demand	g	!0.2183***	0.2131
Cross-elasticity for catfish with respect to pork	α_1	!0.2391**	0.0916
Cross-elasticity for catfish with respect to beef	α_2	0.0074	0.1418
Cross-elasticity for catfish with respect to chicken	α_3	!0.4777**	0.1843
Income elasticity	α_4	0.8916*	0.6671
Population coefficient	α_5	5.7881***	1.4147
Time trend	α_6	!0.0586**	0.0202
R^2 Statistic = 0.95			
Durbin-Watson Statistic = 3.06			
Supply Equation:			
Intercept	β_0	15.7260***	0.2580
Price elasticity of material-input supply	η	0.0911	0.1759
Elasticity of feed supply	β_1	!0.3733***	0.1227
Elasticity of fingerlings supply	β_2	!0.2399***	0.1194
Elasticity of labor supply	β_3	1.0781***	0.0833
R^2 Statistic = 0.92			
Durbin-Watson Statistic = 2.10			
Supply Relation Equation:			
Conjectural variation elasticity	Θ	0.0619	0.0481
Cost of labor	γ_{LL}	14.8420	16.4200
Cost of labor and capital	γ_{LE}	!5.6210	14.2720
Cost of energy	γ_{EE}	7.5110	26.4420
Cost of energy and capital	γ_{EK}	!0.6120	18.4640
Cost of capital and labor	γ_{KL}	0.7330	5.6640
Cost of capital	γ_{KK}	!1.6280	13.1950
R^2 Statistic = 0.91			
Durbin-Watson Statistic = 3.10			
Indices:			
Oligopoly power index	!(Θ/g)	0.2838	0.3725
Oligopsony power index	Θ/η	0.6804	0.9066

Note: Single, double, and triple asterisks (*) denote statistical significance at the 10%, 5%, and 1% levels, respectively.

In addition, while the catfish industry is the largest component of aquaculture in the United States, catfish processing companies are small compared to the dominant food service companies like Sisco and U.S. Service or large retailers such as Wal-Mart. The small size of individual catfish processing plants may partially explain the lack of market power in this and other studies.

Table 3. Parameter Estimates of Conjectural Variation Elasticity

Parameter	Estimate	Standard Error
θ_0	0.075	0.107
θ_1	!0.023	0.301
θ_2	0.001	0.013
θ_3	0.011	0.015
θ_4	0.002	0.004

Table 4. Estimates of Conjectural Elasticity for Selected Years

Year	Conjectural Elasticity	Standard Error
1988	0.069	0.092
1991	0.061	0.077
1994	0.083	0.093
1997	0.134	0.152
2000	0.162	0.183
2003	0.081	0.104
Mean	0.073	0.088

Conclusion

The catfish industry has emerged as the largest component of the U.S. aquacultural sector. The main objective of this paper was to assess the degree of competitiveness in the U.S. catfish industry. To address the objective, a conjectural variation oligopolistic model was developed. The results do give support to competitive behavior of the catfish processing sector.

Conjectural variation models are commonly used in empirical industrial organization because they are able to infer the degree of market power using real data. The conjectural variation approach used here, however, has some limitations in that it does not take into consideration dynamic reactions, and the material input and output conjectural variation elasticities are assumed to be equal.

This study can be extended in many ways. One possible extension is to consider a dynamic conjectural variation model. Another extension is to conduct Monte-Carlo simulations to evaluate the sensitivity of relevant parameters to different functional forms.

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