Intra-processor Price-spread Behavior: Is the U.S. Catfish Processing Industry Competitive?

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An analysis was conducted of price-spread behavior in the catfish-processing sector of the United States. A model of imperfect competition using conjectural variations was used to test for significant deviations from competition. Results show no significant deviation from competitive behavior, suggesting that catfish processors behave competitively. However, this result is limited by the assumption of equal market shares by each catfish-processing firm.

The U.S. Catfish Industry

Catfish production began as a commercially viable enterprise in the late 1960s and early 1970s. Production of food-size catfish has experienced tremendous growth in recent times (13.84 percent from 1991 to 1997 (National Agricultural Statistics Services, various issues)) while the number of catfish producers declined 29 percent from 1989 to 1997. However, the relatively large number of producers that remain (approximately 1,300), freedom of entry and exit, and the inability to set price suggests that catfish production can still be classified as a competitive industry (Dillard, 1995). Dillard states that the four-firm industry concentration ratio (Stigler, 1988; Shughart, 1990) in catfish production has been 10 percent or less, further supporting the competitive market structure hypothesis.

Catfish processing, by contrast, is substantially more concentrated. The four-firm industry concentration ratio was 98 percent in 1979 (Miller, 1981). From 1980 to 1993, the number of catfish processors increased from about 10 to about 30 and has stabilized since that time (Figure 1).

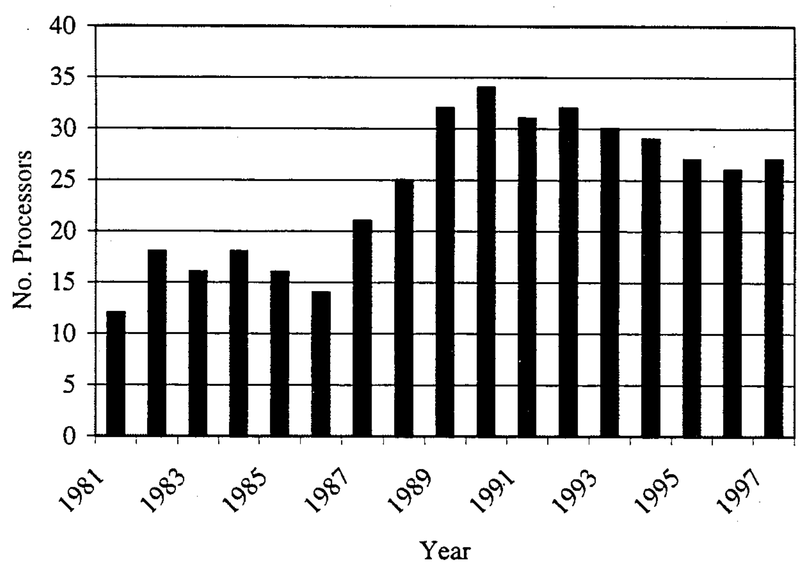

Figure 1. Number of Catfish Processors Operating at the Beginning of Each Year, 1981 through 1997.

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The four-firm industry concentration ratio in catfish processing had decreased to an estimated 60–70 percent by 1995 (Dillard), suggesting a modest shift in industry structure. This change may have implications for price behavior in catfish markets.

Industry concentration prior to 1979 was such that it suggested an oligopolistic market structure, implying Cournot, conjectural variations, or some other oligopoly-type firm behavior. The decrease in concentration (increase in the number of processors) may have led to more "competitive" market behavior. The objective of this paper is to examine the potential impact of the increasing number of catfish processors on price-spread behavior in catfish markets. The present analysis is a departure from the "traditional" farm-retail price-spread analyses in that the subject of this analysis is the price spread between levels of processing or "intra-processor." The point of contention is whether changes in the number of processors have affected price spreads between the final stage of processing and prices of fish at the beginning of processing.

Related Literature

A broad range of literature exists on price-spread behavior in competitive markets. Gardner's seminal work in this area formalized the theory of price-spread behavior in a comparative statics framework. His findings suggest that a simple mark-up pricing rule does not describe price-spread behavior in a competitive food system. The significance of this work is recognizing the role of marketing volume on the farm-retail price spreads in competitive markets. As the quantity of a product moving through the market channel increases, demand for marketing inputs increases. This, in turn, affects the price margin between market levels.

Wohlgenant and Mullen (1987) further built upon this foundation by developing a test to determine if Gardner's relative price model or a mark-up model best empirically described the farm-retail price spread in beef. Using a non-nested technique, these authors found that the relative price model best empirically explained price spreads in the beef industry, which is consistent with the supposition of Gardner. Wohlgenant and Mullen's test was used later by Hudson (1998) to analyze price-spread behavior in catfish markets. This study analyzed price spreads at two different levels of the market channel. The first price spread was between the farm and the first stage of processing while the second was between levels of processing. Findings from this study indicated that the performance of a mark-up pricing model was superior by empirical standards in explaining farm/processor and intra-processor spreads in catfish markets. However, as the number of processors increased, margins tended to decrease.

The hypothesis offered as an explanation for this result was that the level of competition may have been increasing over time. The overall result of that study would suggest that the catfish market is not competitive. However, this is not direct evidence of market structure or performance. The ambiguity of the result in Hudson (1998), with respect to market structure and performance, suggests a need to view price-spread behavior from a more appropriate empirical perspective. The method provided by Wohlgenant and Mullen (1987) is adequate for competitive industries but does not allow a direct test of market behavior (Holloway, 1991). Some imperfectly competitive market models are fruitful in that regard.

Literature on imperfectly competitive markets is somewhat less abundant but still prevalent. Schroeter and Azzam (1991) analyzed the farm/wholesale margin in the pork industry, accounting for the factors of market power and risk. Using conjectural variations, these authors found that competitive performance in the market was maintained despite the dramatic increase in packer concentration. Conjectural variation was also employed by Sexton (1990) in his analysis of the role of cooperatives in agricultural markets. As a departure from the conjectural variations model, a dominant firm/competitive fringe model was employed by Buschena and Perloff (1991) in their analysis of market power in the coconut oil export market. This area of literature demonstrates the applicability of imperfectly competitive models to various food industries.

One paper by Kouka (1995) is particularly relevant to this analysis in that he estimated the value of the conjectural elasticity and oligopoly power index for the catfish industry. Using annual aggregate data, he found evidence to support a conclusion of oligopoly structure in catfish processing. However, the approach offered by Kouka does not lead to a testable hypothesis for market structure. His conclusions do suggest a potential change in market behavior through time, a result also pointed to by Hudson (1998).

Holloway formalized the concept of farm-retail price spreads in imperfectly competitive markets by examining the role of conjectural elasticities inside Gardner's (1975) framework. The author develops the necessary and sufficient conditions for perfect competition in the food industry. Through this formulation, Holloway (1991) further develops an empirical framework by which to test the hypothesis of competition (specifically, competitive behavior) in food markets. Access to this procedure affords the ability to test the competitiveness of catfish processors.

Analytical Model

One appealing feature of Holloway's (1991) model, in terms of the present study, is the endogeneity of the number of processors; Holloway makes explicit the entry and exit of processing firms into market behavior analysis. This is relevant to the current study because of the large increase in the number of processors in catfish processing during the past two decades. The following discussion draws heavily on the derivations in Holloway, but only necessary portions of his approach are reproduced here.

Given an industry demand function, each firm i forms its conjecture about the relationship of its own output to industry output, $QFL = K_i(QFL_i)$ (where QFL is the quantity of fillets produced). According to Applebaum (1982), the elasticity of industry output conjectured by firm i, θ_i, is given as

$$\text{(1)} \qquad \phi_i = \partial K_i / \partial QFL_i \, (QFL_i / QFL).$$

If C is defined as the firm's marginal cost and η is the market price elasticity of demand for catfish fillets, each firm's first-order condition for profit maximization is given by

$$\text{(2)} \qquad P_{QFL}(1 + \theta_i / \eta) = C.$$

The marginal cost function, C, is defined over the price vector (P_a, P_b) and corresponds to a linearly homogeneous technology in two variable inputs (a_i, b_i). The two variable inputs are the firm's quantity of fresh whole catfish (farm commodity) and labor (a marketing service input), respectively. All firms have the variables P_{QFL}, η, and C in common, implying that $\theta_i = \theta_j = \theta$ $\{i \neq j\}$. Holloway also assumes that $QFL_i = QFL_j = QFL_n = QFL/n$, or that each firm produces the same level of output.[1] This simplifying assumption of symmetric equilibrium is made for analytical clarity.

Equation (2) provides useful results for the current analysis. In one extreme, $\theta_i = 1$ indicates cartel or monopoly behavior. By contrast, $\theta_i = 0$ indicates perfect competition. Thus, it would be appealing to test for $\theta_i \neq 0$, an indication of imperfect competition. A good deal of Holloway's (1991) comments (pp. 982–986) are devoted to deriving an approach for this test.

One interesting result from this derivation is the similarity of Holloway's results to Gardner's (1975) when $\theta_i = 0$. That is, when $\theta_i = 0$, cost shares reduce to revenue shares, forcing the firm-entry condition moot. Thus, when $\theta_i = 0$, firm entry is not a factor in farm-retail price spreads, implying competitive markets. This further suggests that firm entry, as is important in the current study, can have an impact on price-spread behavior in less than perfectly competitive industries. Also important to this analysis, as the number of firms increases, price behavior more closely approximates the competitive situation (that is, $\theta_i = 0$) for Cournot competitors. Given that $\theta_i \approx 0$ generates a result consistent with the competitive solution, the question becomes: Is $\theta_i > 0$ so that it can be said to be statistically different from zero? This question is addressed in the Methods section.

Some attention should be given to the necessary and sufficient conditions for perfect competition in food markets. Based on Holloway (1991, see pp. 984–985 for a more detailed discussion), there are three necessary and sufficient conditions for perfect competition. The first condition is that the elasticity of changes in the price of fresh whole catfish—with respect to changes in demand

[1] The potential implications of this assumption are explored later in the paper.

for catfish fillets—must equal the negative of the elasticity of changes in the price of fresh whole catfish—with respect to changes in the supply of fresh whole catfish. This is analogous to saying that $\theta\eta = 0$, which implies that either $\theta = 0$, $\eta = 0$, or both. Even in the case of perfectly inelastic demand, Holloway shows that $\theta = 0$, implying that the above restriction is a sufficient condition for competition.

The second condition, similar to the first, is that the elasticity of changes in the price of catfish fillets—with respect to changes in the demand for catfish fillets—must equal the negative of the elasticity of changes in the price of catfish fillets—with respect to changes in the supply of fresh whole catfish. This is sufficient to show that $(\theta/(\theta + \eta))w_b\sigma = 0$, where w_b is the cost share for the non-farm input and is the elasticity of substitution between catfish and the marketing (non-farm) input. Because $w_b > 0$ by assumption, this condition implies that either $\theta = 0$, $\sigma = 0$, or both, suggesting the need to test H_o: $\sigma = 0$ as well as H_o: $\theta = 0$ in an equation involving the price of catfish fillets. The possibility of $\sigma \neq 0$ implies the need for another restriction. According to Holloway, this restriction is imposed when the elasticity of changes in the price of catfish fillets—with respect to changes in the price of the marketing input (labor)—is forced to be equal to zero.

Methods

The above restrictions were tested using the following three equations of the catfish market:

$$(3)\quad R_t^* = \alpha_1 QFL_t^* + \alpha_2 QF_t^* + \alpha_3 P_{L,t}^* + \varepsilon_{R,t},$$

$$(4)\quad P_{QFL,t}^* = \beta_1 QFL_t^* + \beta_2 QF_t^* + \beta_3 P_{L,t}^* + \varepsilon_{Pqfl,t},$$

$$(5)\quad P_{QF,t}^* = \phi_1 QFL_t^* + \phi_2 QF_t^* + \phi_3 P_{L,t}^* + \varepsilon_{Pqf,t},$$

where R is the ratio of the processor price of catfish fillets (P_{QFL}) to the processor price for fresh dressed catfish (P_{QF}), QFL is the quantity of fillets sold by processors, QF is the quantity of fresh whole fish processed by catfish processors, and ϵ_j is the disturbance term for each equation. The asterisks denote the transformation of those variables into the first difference in logarithms (for example, $R_t^* = \ln(R_t) - \ln(R_{t-1})$). This is a conversion from the instantaneous relative changes in the variables ($R^* = \Delta R/R$) as per Wohlgenant.

The price spread formulated here is not a true farm/processor spread in the sense that the input price used here is for fish that has undergone the initial stages of processing (that is, has been skinned and gutted). An important note about the selection of this variable should be made. Catfish meant for fillets bypass this first stage of processing (dressing) and move straight into filleting machines. Fresh dressed fish are typically bound for consumption rather than for further processing. One potential limitation of using this series is that the price of fresh dressed fish could be subject to slightly different market forces than fillet prices could. However, the price for fresh dressed fish does represent what the value of the fish is, net by-products; thus, it is used as a proxy for the price of the raw input into fillet processing.

The second price (the price of fillets) represents what the processor received for the finished product. This margin can be more accurately described as the within or "intra-processor" price spread. The limitation of this approach is that it does not test the market behavior of the entire catfish industry. It does, however, test the behavior of the processing subsector, which is the focus of this study.

To test for the potential of competitive market behavior, equations (3) through (5) were first estimated without the necessary conditions imposed. The second step in this analysis is to estimate equations (3) through (5), imposing the restrictions on price elasticities (not on the elasticity of substitution). That is, in the second step, $\alpha_1 = -\alpha_2$, $\beta_1 = -\beta_2$, and $\theta_1 = -\theta_2$ restrictions were imposed on equations (3) through (5), respectively. Under H_o: $\theta = 0$, the F-values resulting from these restrictions will not be significantly different from one at the 5 percent level of significance.

Two empirical points should be noted. First, there is reason to believe that the disturbance terms for equations (3) through (5) will be contemporaneously correlated. However, because there are no cross-equation restrictions, and the same independent variables appear on the right-hand side of the equations, the ordinary least squares regression (OLS) is still applicable (Holloway, 1991). Second, deflating the price series imposes a zero homogeneity restriction, which yields efficient estimates under the assumption of perfect competition but limits inferences about market behavior. Thus, equations (3) through (5) were estimated with prices in nominal form.

The final step in this analysis was to test H_o: $\sigma = 0$, or the elasticity of substitution between inputs is equal to zero. This is only relevant to the retail price equation (4). The restriction is accomplished by jointly estimating the effects of the restrictions $\beta_1 = -\beta_2$ and $\beta_3 = 0$. If $\beta_1 = -\beta_2$ yields the result that $\theta = 0$ and if $\sigma \neq 0$, the market is concluded to exhibit a competitive market structure.

Data for this analysis were monthly price and quantity data for catfish (National Agricultural Statistics Service, various issues) and monthly average wage rates in food processing industries (Bureau of Labor Statistics, 1998) for the period 1986 through 1993. That time period was selected for two reasons. First, the period exhibited the most growth in the number of processors (Figure 1). Thus, changes in market behavior would be expected to be most prevalent over that time period. Second, a reliable, consistent set of data was readily available during that time period.

Results

The results of the unrestricted regression are shown in Table 1. Each of these regressions showed signs of first-order autocorrelation, so the parameters were adjusted using a Cochrane-Orcutt transformation, resulting in the parameter (elasticity) estimates found in Table 1. The signs on the estimates are consistent with *a priori* expectations, with the exception of the equation for the fillet/fresh fish price ratio. The sign on the elasticity of this ratio, with respect to changes in the demand for catfish fillets, was expected to be negative; however, this variable is not statistically significant. The implication of this equation is that only changes in wage rates (a proxy for changes in marketing input prices) affect changes in the fillet/fresh fish price ratio. This result is consistent with the finding by (Hudson, 1998) in that the volume marketed had no effect on the price ratio. What may have generated this ambiguous result is the fact that both farm output and finished product demand were expanding rapidly over the period of analysis so that the effects of volume on the price ratio were masked. This issue is discussed in more detail below. Both price equations, however, exhibited results consistent with prior theoretical development.

Table 2 shows the results of the restricted regressions. For the fillet/fresh fish ratio, the restriction of $\alpha_1 = -\alpha_2$ is marginally restrictive at the 5 percent level of significance (that is, $\theta \neq 0$) (in fact, the p-value on the F-test was 0.05039). This would suggest that the catfish-processing subsector is imperfectly competitive. However, the results for the two price equations suggest an opposite conclusion (that is, $\theta \neq 0$). The marginal significance of the result for the price ratio equation and the failure to reject $\theta = 0$ in the price equations suggests that perfect competition is the conclusion to be drawn for the catfish processing subsector. The sufficiency of these estimated results for a conclusion of competition is further tested using the fillet price equation (4) and restricting $\beta_3 = 0$. These results are shown in Table 3 and provide strong evidence that $\sigma \neq 0$, further supporting the conclusion of competitive behavior.

Table 1. Results of the Unrestricted Regression.

		Estimated Elasticities with Respect to:		
Price		Fillets Sold	Fresh Whole Fish	Wages
Ratio		0.016703	0.017209	.51193
		(0.4487)[a]	(0.3881)	(6.339)
	$R^2 = .973$			
Fillets		0.05805	-0.066319	0.5359
		(2.547)	(-2.44)	(10.81)
	$R^2 = .981$			
Fresh Fish		0.12213	-0.13954	0.35064
		(2.784)	(-2.707)	(3.805)
	$R^2 = .7664$			

[a] The numbers in parentheses are t-values; degrees of freedom = 89 for each equation.

Table 2. Results of Restricted Regression.

Price		Estimated Elasticity with Respect to:		
	F-value[a]	Fillets Sold	Fresh Whole Fish	Wages
Ratio	3.9356	-0.040356	0.040356	0.60127
		(-0.8456)[b]	(0.08456)	(18.36)
$R^2 = .9687$				
Fillet	1.0327	0.074163	-0.074163	0.51080
		(2.535)	(-2.535)	(25.44)
$R^2 = .9783$				
Fresh Fish	0.81034	0.1513	-0.1513	0.30177
		(3.009)	(-3.009)	(8.742)
$R^2 = .7542$				

[a] F-value for H_0: $\theta = 0$.
[b] The numbers in parentheses are t-values; degrees of freedom = 89 for each equation.

Table 3. Results of Additional Restricted Regression for the Test of $\sigma = 0$.

Price		Estimated Elasticity with Respect to:		
	F-value[a]	Fillets Sold	Fresh Fish	Wages
Fillet	324.26	-0.61994	0.61994	0
		(-20.55)[b]	(20.55)	
$R^2 = .8225$				

[a] F-value for the test of $\sigma = 0$.
[b] The numbers in parentheses are t-values; degrees of freedom = 90.

The ambiguous result with respect to the price ratio equation is somewhat puzzling when viewed in conjunction with the other results. One plausible explanation for this result, alluded to earlier, is the rapid expansion of farm output of catfish and the corresponding expansion in demand for catfish. It has been shown that farm price can, in fact, increase with an outward shift in farm output (Chen and Lent, 1992). Specifically, this result is more likely to because of the fact that the increases in farm output are likely to stimulate entry into food processing (Hamilton and Sunding, 1997). Thus, expanding farm output may serve to "mask" the effects on the price ratio between market levels when viewed in light of these findings.

Another factor that does not appear to be directly addressed by either Holloway (1991) or the present model is the potential for "competition-mimicking" market structures. Market structures, such as contestable markets (Baumol, Panzer, and Willig, 1982), or other zero-profit imperfectly competitive models are known to generate behavior consistent with competition but are not "competitive" in structure. The result of a contestable market is the situation where P = MC = AC or no long-run profits are possible. Thus, it is possible to observe competitive behavior without competitive structure. This may be the case in catfish processing. That is, Dillard found the four-firm industry concentration ratio to be in the 60–70 percent range but also found that no long-run profits have been observed in the industry. This issue deserves further attention in both theoretical and empirical studies of performance.

Another interesting note is that these findings are obvious contradictions to those of Kouka (1995). However, Kouka was using annual data over a longer time period (1977 through 1993). This study confined the period of analysis to the 1986 through 1993 period but used monthly data. Confining the sample to the period of rapid growth in the number of processors may have served to "bring out" the effects of firm entry as compared to the longer time periods used by Kouka. This may be especially true given that much of the time period in Kouka's analysis is characterized by "extreme" industry concentration (Dillard, 1995; Miller, 1981).

Conclusions and Caveats

The relative newness of the catfish industry has, to this point, precluded any extensive analyses of the performance of the catfish marketing system. This analysis marks a major step in understanding the behavior of catfish processors. It is reasonably clear from this analysis that behavior in the catfish processing subsector has not deviated significantly from competitive behavior over the period studied. However, it also seems clear that the issue of structure is somewhat ambiguous. Prima facie evidence would suggest that the structure cannot be classified as competitive. Rather, other structures such as contestable markets may be more representative. Nonetheless, no direct evidence in that regard is offered here.

An important limitation to this study should be mentioned. Holloway's (1991) model assumes that each firm's output is equal, generating equal conjectural elasticities. The assumption that total output is divided equally among firms automatically forces the condition of equal market power. This necessarily limits inferences that can be made about the conjectural elasticity to situations that closely resemble this assumption. Holloway states that this limitation becomes less important as the number of firms increase, but that is assuming that output is relatively evenly distributed. This assumption makes the model analytically appealing but may serve to be too restrictive empirically. Because of analytical intractability, relaxing this assumption may involve more empirical exploration.

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