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Changes in Price Behavior in the U.S. Catfish Industry: Evidence Using Cointegration

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The implications of market development in the catfish industry on catfish price behavior are explored using cointegration. It is hypothesized that market development, through increases in competition between processors and shifts in consumer preferences toward fish, has caused changes in price behavior among levels of the catfish market. Using monthly catfish price data, a cointegration analysis of subsets of prices shows that price behavior has changed through time, with catfish prices becoming integrated as the number of processors has increased. These results may have implications for the examination of market price behavior in developing or emerging markets.

Key Words: catfish, cointegration, price behavior, vertically related markets

Developing Markets

The issue of developing or emerging markets has been a timely topic of late due to the increasing amount of niche market products such as organically grown commodities or new commercial applications of existing "traditional" commodities. There is a broad range of literature discussing various aspects of these products and product markets. For example, Fuller, Bello, and Schafer analyzed factors affecting the price of subtropical peach production. Other concerns, such as trade policies (Koo, Golz, and Yang) and buyer concentration (Bailey, Brorsen, and Thomsen), also have been addressed.

One element that appears to be relatively overlooked in the literature is the changes in price behavior which occur through the process of market development. Tomek and Robinson provide a solid overview of factors that will affect pricing relationships. For example, as buyers of a product become larger and more concentrated, they would be expected to move away from open competition for products to more contracting or formula pricing. Conversely, as the number of buyers increases or becomes less concentrated, one would expect more price competition among buyers.

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Information and information technology likely have a role in the market development process and price behavior. As information becomes more readily available, the economic cost of searching out and using that information decreases. The access to lower cost information will tend to enhance the efficiency of the market, provided that information is correct (Hudson, Ethridge, and Segarra). In a developing market, market information may be relatively scarce. Improvements in information may assist in the market development process by streamlining transactions costs and increasing the overall efficiency of the industry.

All of these factors (and others) potentially contribute to the development of markets. As these factors converge and markets progress through the development process, changes in price behavior likely occur. In vertically related markets, prices at different levels are expected to show a closer relationship with one another as information and other market forces generate long-term relationships between prices.

The U.S. Catfish Industry

The catfish industry is a rapidly growing industry, exhibiting 13.84% annual growth in foodsize[1] production from 1991 to 1997 [U.S. Department of Agriculture/National Agricultural Statistics Service (USDA/NASS), 1980–97]. Many changes have occurred in the industry in recent years. The number of producers declined 28% from 1991 to 1997. Despite this decline, catfish production probably can still be classified as a competitive industry because of the large number of producers and the inability to set price (Dillard). Dillard also reports that the four-firm industry concentration ratio for catfish production consistently has been 10% or below.[2]

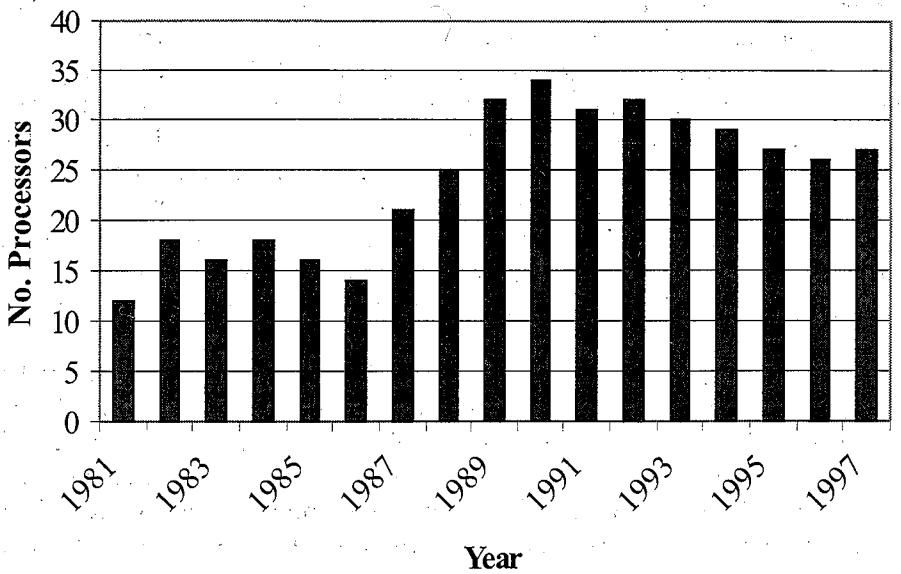
In contrast, the processing sector of the catfish industry is highly concentrated. In 1979, the four-firm industry concentration ratio was 98% (Miller). From 1981 to 1993, the number of processors increased from approximately 10 to about 30 (figure 1), suggesting an increasing level of competition. In fact, the four-firm industry concentration ratio had decreased to an estimated 60–70% by 1995 (Dillard). While this certainly does not indicate a competitive industry, it does suggest a modest change in the industry structure, which may have led to changes in pricing behavior.

Literature on catfish markets is somewhat limited. Ligeon, Jolly, and Jackson examined the impacts of the North American Free Trade Agreement (NAFTA) on the catfish industry. More general marketing issues have been addressed by Schupp and Dellenbarger and by Capps and Lambregts, and some work also has been done by Murphy and Willett on the development of cooperatives in the catfish industry.

A number of studies have focused on pricing in the catfish industry. Kinnucan et al. examined processor demand and the effects of off-flavor on catfish prices. Other

[1] Foodsize catfish, in general, are catfish weighing from three-quarters of a pound to over three pounds. Growth in foodsize production was measured as the growth in the total pounds processed annually.

[2] The four-firm industry concentration ratio is defined as the market share held by the top four firms as a group (Stigler; Shughart).



Source: USDA/NASS, *Catfish Processing* (various years).

Figure 1. Number of catfish processors operating at beginning of each year in the U.S., 1981–97

investigators (Kinnucan; Kinnucan and Sullivan; Kouka) explored issues of market structure and conduct. In separate studies, Nyankori, and Zidack, Kinnucan, and Hatch analyzed price transmission in catfish. The latter two works are particularly relevant to the current analysis in that price transmission is an important indicator of the relationship between prices at different levels of the market.

The rapid increase in catfish production and processing, and potential increases in competition in catfish processing, suggest a need to examine catfish prices and price relationships. The developing nature of the catfish market in the past decade also could give an indication of how price behavior changes through the market development process. Thus, the objective of this study is to examine the relationship between prices at the producer and processor levels of the catfish industry.

Discussion of Market Development

The issue of a developing market is intriguing, with many dynamics and potentially different paths that a market can take. Bressler and King discuss the development of the U.S. economy and markets within that economy. From a historical perspective, there are many factors that may have contributed to the development of U.S. markets, including abundant natural resources and the development of infrastructure.

In terms of market development, there are some insights that can be drawn from this historical perspective. For instance, lack of infrastructure increases transactions costs, thereby increasing the probability for divergence of price behavior between spatially separated markets (i.e., increased transactions costs limit arbitrage between markets). That is, if it costs 25¢/pound to transport cattle from one market to the next because of poor roads, the two markets can differ by as much as 25¢/pound in price before it would pay to transport between markets to capture the benefits of the price difference. Thus, improving infrastructure (not just roads, but such dynamics as communications, production, and transportation technology) would be expected to increase the "efficiency" of the market by bringing price behavior in different markets in line with one another.

Another example of market development is in the area of vertically related markets (i.e., one market produces the raw product for a processing market), where a major component is the development of "institutional arrangements." To illustrate, in the early stages of market development, producers of a product may have little knowledge of where to market their product. As time progresses, producers and processors begin to develop established channels through which the product passes. More marketing alternatives become apparent to the producer as the channels become more firmly established and widely used, allowing the producer to develop marketing strategies that maximize profit. This process continues so that arbitrage forces prices in different market channels together, which, when viewed empirically, exhibits "efficient" behavior. This process might occur because the number of processors has increased, thereby increasing the level of competition for the raw product, or it might be a result of the availability of more information in the marketplace so that producers can actively bargain among processors to secure the highest possible price (or likely some combination of the two). Whatever the true nature of the catalyst, the result is that the prices between market levels are expected to exhibit a higher degree of integration, or the markets are expected to become more efficient.

This discussion provides some indication of what to expect in catfish markets. Commercial catfish production is a relatively new enterprise compared to other major food and fiber processing sectors (commercial catfish production began in the late 1960s). As such, it likely has been going through this "development" process in the past decades. There are two potential sources of changes in price behavior in catfish markets. First, rapid increases in catfish consumption may be indicative of the general shift in U.S. consumer tastes and preferences away from red meat to more fish and poultry. This shift in tastes and preferences (as alluded to by Tomek and Robinson) likely leads to changes in pricing relationships within the market for that good. The shift in preferences toward fish may have increased competition among processors to supply those fish products demanded by consumers. The competition among processors may have given catfish producers more opportunities to exploit alternative market channels, thereby forcing alternative channels to behave similarly in their buying behavior. If this situation is true, it would be reasonable to expect that changes in the price of processed fish would be passed directly to catfish prices at the producer level. Thus, through the progression of time, changes in prices at different market

levels would be expected to begin to mirror one another. On this basis, it is hypothesized that the shifting of tastes and preferences has forced the prices of catfish at different market levels to become more integrated through time.

The second source of changes in price behavior, which cannot be completely separated from the first, is the increase in the number of catfish processors. Figure 1 shows that the number of catfish processors in the United States (at least those reported by the USDA) grew substantially in the past two decades. This increase, and the corresponding decrease in industry concentration (Dillard), may be reflecting an increase in the level of competition in catfish markets. Recent research has shown that the increase in the number of processors has had a significant effect on the size of farm/processor margins (Hudson). Thus, it is reasonable to expect that the increase in the number of processors also will have an effect on the integration of market prices between market levels.

Methods

There are several potential reasons why markets might not operate as efficiently (i.e., might not be as integrated) in earlier stages of development as in later stages. To examine this hypothesis, a data set of monthly average farm- and processor-level prices was collected for the 1980–93 period. This time period was chosen because it exhibits the most growth in the number of processors. As shown in figure 1, the peak in the growth of the number of processors occurred in 1990, and has remained relatively stable since that time. Therefore, the 1980–93 time period provides the best subset of prices for examining changes in market price behavior with potential changes in market structure, competition, and related areas.

A cointegration test (Engle and Granger) was used to evaluate the price relationships between producer and processor prices in the catfish market. This technique has been widely applied in the analysis of market efficiency (see, e.g., Varangis; Schroeder and Goodwin; Ardeni).[3] The importance of cointegration in this analysis is that it shows the relationship between catfish prices at different market levels. The interest is not in drawing specific conclusions about market efficiency, but in examining changes in the relationship of prices between market levels over time.

Engle and Granger state that two series may be nonstationary by themselves, but a linear combination of those series may result in a stationary error term. More specifically, if the two price series are integrated to the same order (usually the first order), and the resulting residuals of their linear combination are stationary, the series are said to be cointegrated. In the catfish market, the prices under consideration are the monthly average producer-level prices of catfish in cents per pound (P_F) and the monthly average prices of whole fresh catfish in cents per pound (P_W),[4] so that:

[3] There have been recent criticisms of the use of cointegration in examining spatial pricing efficiency (Baulch; McNew and Fackler). Because spatial pricing efficiency is not at issue here, those criticisms do not apply.

[4] Fresh whole catfish is defined as those fish that have been gutted and skinned.

(1) $$P_F = \alpha + \beta P_W + \varepsilon_t.$$

To analyze the stationarity of the error term, equation (1) is rewritten as:

(2) $$P_F - \alpha - \beta P_W = \varepsilon_t.$$

Both P_F and P_W were tested for a unit root using the augmented Dickey-Fuller test (Madalla), and both were found to be nonstationary in the levels but stationary in the first differences (i.e., both were integrated to the first order). Because both are integrated at the same level, this ensures the applicability of the cointegration test. If ε_t in equation (2) is stationary, then the series are said to be cointegrated. If they are not cointegrated, then one price series cannot be predicted from the other—and no long-run relationship exists between the series. The implication of cointegration in terms of this analysis is that the market prices at different market levels are moving together, consistent with what would be expected in a "developed" market. A finding of no cointegration indicates that, for some reason, prices are not moving together.

Changes in price behavior over time were evaluated by breaking the data up into two-year, overlapping increments. That is, the first period of analysis was the period 1980–82, the second 1981–83, and so on, until the entire data set was covered. The period of two years was arbitrarily selected for two reasons. First, two years should be sufficiently long to identify trends in prices. Second, two years should be sufficiently short to identify changes in the price behavior over time.

There are several methods of testing for cointegration (Engle and Granger). However, the simplest method is to evaluate the Durbin-Watson statistic resulting from equation (1), as was done for this analysis. One advantage of estimating the price relationship in this fashion is that it allows the direct derivation of the price transmission elasticity, calculated as:

(3) $$\frac{\partial P_W}{\partial P_F} \times \frac{P_F}{P_W} = \frac{1}{\beta} \times \frac{P_F}{P_W}.$$

This elasticity was calculated for each time period for which there was a regression, which should give some indication of changes in price responsiveness between market levels through time. However, it should be noted that these are only rough estimates because the price equations are not fully specified price spread models.

Results

One cointegration regression was conducted for the entire study period (1980–93) to serve as a basis for comparison. The resulting Durbin-Watson statistic was 0.209, indicating that the hypothesis of no cointegration could not be rejected at the 10% level of significance. This suggests that, in general, prices for catfish at different

Table 1. Durbin-Watson Statistics and Price Transmission Elasticities for Time Period Cointegration Regressions

Time Period	Durbin-Watson Statistic	Price-Transmission Elasticity[a]
1980–1982	0.183	0.989
1981–1983	0.155	0.896
1982–1984	0.237	0.623
1983–1985	0.389	0.696
1984–1986	0.808*	0.841
1985–1987	0.874*	0.781
1986–1988	1.033*	0.742
1987–1989	0.571*	0.719
1988–1990	0.631*	0.720
1989–1991	0.561*	0.787
1990–1992	0.467*	0.804
1991–1993	0.410*	0.825
1984–1993	0.437*	0.874

Note: An asterisk (*) denotes that cointegration is present at the 5% level of significance.

[a] Elasticity of changes in whole fresh fish prices with respect to changes in farm price.

market levels do not move together. It could be concluded, then, that either: (*a*) the catfish market is inefficient, or (*b*) the market has not sufficiently evolved to the point where it exhibits price behavior consistent with more "developed" markets.

When the data are broken down in the manner described above (in two-year increments), an interesting pattern emerges. Table 1 shows the Durbin-Watson statistics for each time period's regression. What can be observed is that the level of market price integration tended to increase through time. That is, in the early periods of the analysis, market prices between the producer and processor levels tended not to be highly related. Such a finding is consistent with what was expected, from the perspective that this would have been the time period the catfish market was "developing." The number of processors was relatively small and industry concentration was high during this period, which may imply that significant price competition was not present.

As time progressed (and presumably as markets became more developed), the level of market integration increased. After the 1984–86 period, farm- and processor-level catfish prices were consistently cointegrated, indicating that those market prices tended to move together. This result reveals that as time progressed, price changes at the processor level tended to be mirrored by price changes at the producer level, or the

two market levels were integrated. To ensure that this finding was consistent when viewed from a longer term, a regression on the period 1984–93 was estimated, and those results are shown in the last row of table 1. Based on this regression, prices were found to be cointegrated over the 1984–93 period, suggesting that the findings from the individual subperiods were consistent.

The implication of these results is that as time progressed, catfish prices began to behave as would be expected of "developed," vertically related markets. This also begs the question of why price behavior would change. One plausible explanation is the role of increasing competition. As stated earlier, the four-firm industry concentration ratio in the processing sector decreased substantially over the period of analysis. Figure 1 reflects this increase in the number of processors. What may have occurred is that as the number of processors increased, the level of competition among processors and/or the establishment of institutional arrangements between producers and processors may have forced prices to be more closely aligned, thus giving the result of cointegration.

Alternatively, the change in price behavior may have been due in part to the shift in consumer tastes and preferences, resulting in increased demand for fish. These two explanations cannot be separated, and provide essentially the same rationale for the results found here.

There is some variation in the estimated price transmission elasticities over time (as can be seen in table 1). The most variable period was when prices were not cointegrated. After 1984, the elasticities tended to stabilize, generally above 0.72. The resulting long-run price transmission elasticity coming from the regression on the 1984–93 period was 0.874. This is slightly higher than Zidack, Kinnucan, and Hatch's estimate of 0.68. The differences likely can be attributed to the specification of the wholesale price of catfish used by Zidack, Kinnucan, and Hatch, and that their model was a more fully specified set of price equations.

Conclusions

This analysis points to the conclusion that price behavior in catfish markets has changed over time. Results suggest that a definitive pattern emerged from the data showing that prices at different market levels tended to become more integrated as time passed. This finding suggests two general interrelated conclusions. First, the catfish market has tended to become more "efficient" in terms of the price relationship between market levels with passage of time. Second, market development tends to increase the efficiency of price transmission. With no direct evidence of "market development," one is left to speculate what forces may have triggered this transformation in the catfish market. Future research should be designed to address those questions.

In a more general sense, this analysis indicates the need for careful attention when examining markets that are developing. That is, a cointegration analysis of the entire time period (1980–93) would have shown that the catfish market is inefficient.

However, closer examination of subperiods reveals that price behavior has changed, and the market actually could be deemed to be "efficient." This clearly suggests that researchers should approach these markets with caution before making final conclusions about efficiency.

Two limitations of this research should be noted. First, price relationships to the consumer level were not examined. Much of the retail-level data on catfish prices are proprietary and were not available for this analysis. Second, no attempt was made to examine the specific nature of the price relationship between market levels (i.e., no specific functional relationships between prices were explored). Given the evidence presented here, one suggestion for further research would be to estimate a time-varying parameter model of the price relationship between market levels in order to identify the nature of the changes between prices at different market levels.

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