The Impacts of Ethanol on the US Catfish Farm Sector*

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Summary: In this study, we estimated catfish feed and farm price reduced form equations. Of particular importance was the impact of the recent increase in grain prices induced by ethanol production on feed cost and farm prices. This relationship was examined using an autoregressive distributed lag (ARDL) model. Results show that a 1% increase in corn prices caused a 0.134% and 0.263% increase in feed prices in the short- and long-run, respectively. Catfish farm prices increased by 0.106% (short-run) and 0.211% (long-run) given a 1% increase in feed prices.

Between 2004 and 2008, corn prices increased from $2 to $6 per bushels. Taheripour and Tyner (2008) state that of the total increase, 25% was due to US ethanol subsidies and 75% was due to the increase in the price of crude oil. Given the $1 increase in corn prices (50%), this should result in a feed price increase of 13% and a farm price increase of 2.7% in the long-run. Park and Fortenbery (2007) found that for every percentage increase in ethanol production, corn prices increased by 0.16 % in the short run. From this we conclude that a 100% increase in ethanol production will cause catfish feed prices to increase by 4.21% in the long run, and catfish farm prices to increase by 0.89%.

Key Words: Catfish price, catfish feed, ethanol, autoregressive distributed lag (ARDL) model

1. Introduction

From 2000 to 2007, ethanol production increased from 1.6 billion gallons to approximately 6.5 billion gallons, an increase of more than 400% (Collins, 2007). Because corn is the primary ingredient in US ethanol production, corn production has expanded and corn prices have significantly increased. According to National Agricultural Statistics Service (NASS), the average farm

level corn price in 2005 was $1.96 per bushel. Corn prices increased from $2.00 per bushel in January 2006 to $3.01 in December 2006. Corn prices reached a peak of $5.48 per bushel in June 2008.

The increase in catfish feed cost induced by the recent rise in corn prices (as well as other grains) has negatively impacted US catfish farmers. The severity of the present outlook for catfish farmers received national attention in the New York Times and the USA Today. Both news publications acknowledge that the increase in corn and soybean prices, which is often attributed to the growth in US ethanol and biofuels production, has resulted in farm closures in a number of catfish producing states (Byrd, 2008; Streiteld, 2008).

Arkansas, Louisiana, Alabama and Mississippi account for almost all US catfish production. Byrd (2008) notes that in 2008, the price of farm-raised catfish in these states was about $0.80 per pound, but the production costs were as high as $0.90 cents per pound. In the face of consistent negative returns, catfish farmers are draining their ponds and many employees in the catfish sector have lost their jobs in the process.

The primary objective of this study is to assess how catfish farm prices are directly impacted by feed prices, and indirectly impacted by the price of corn and other grains. Of particular importance is the impact of the recent increase in grain prices induced by ethanol production. To accomplish this objective, catfish farm price and feed price reduced form equations are estimated by applying an autoregressive distributed lag (ARDL) model. Model estimates are used to assess the dynamic relationship between ethanol production and the catfish farm sector.

2. Background

Regardless to the feed formula, corn and soybean meal are always key ingredients in making the least-cost and most nutritious catfish feed, followed

by cottonseed meal and wheat middling. For instance, catfish feed that is 32% protein, contains about 32.1% corn grain, 41.6% soybean meal, 10% cottonseed meal, and 10% wheat middling (Robinson et al., 2006).

As shown in Figure 1, there is a strong relationship between catfish feed prices and corn prices. In 2001, the average feed price was $205.75 per ton. Feed prices increased throughout 2006 and 2007 reaching $337.48 per ton in December 2007.

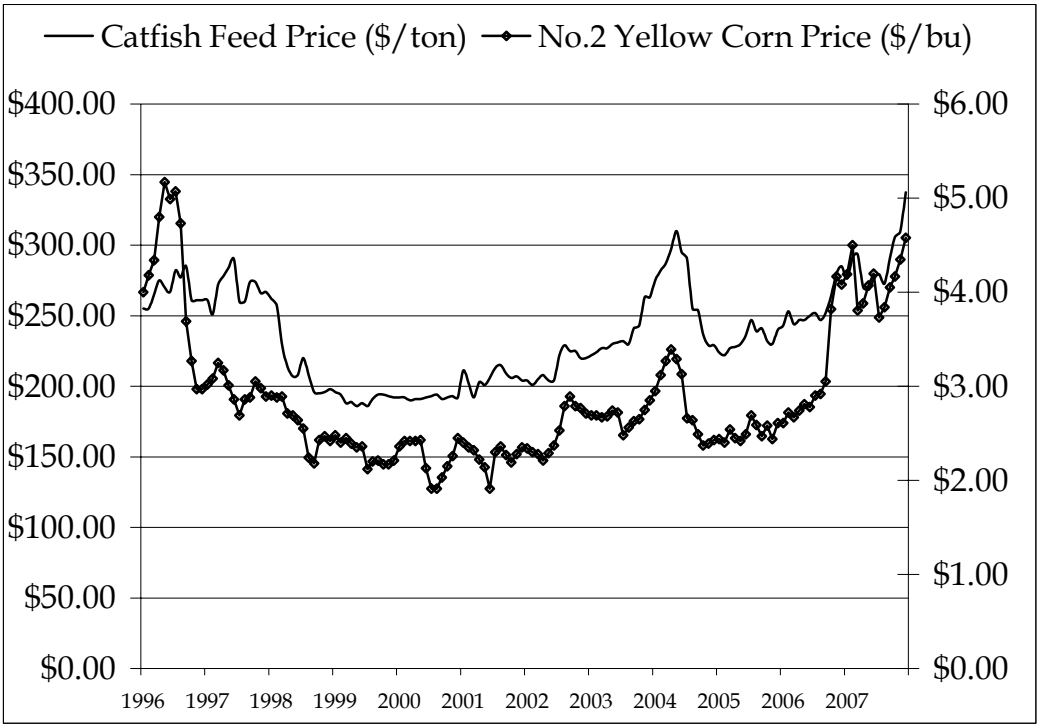

Figure 1. Catfish Feed and Corn Prices: 1996-2007 (Source: NASS and ERS)

According to Figure 2, the average corn price (farm level) in 2005 was $1.96 per bushel. Corn prices increased from $2.00 per bushel in January 2006 to $5.50 in April 2008. From 2005-2008, the price of soybean meal, cottonseed meal, and wheat middling also increased. In 2005, the average price of soybean meal was $189.29 per ton; however, prices increased throughout 2006 and 2007 reaching $412.25 per ton in July 2008. Cottonseed meal prices

increased from $112.50 per ton in January 2005 to over $335.00 per ton in 2008. The increase in wheat middling prices is more recent.

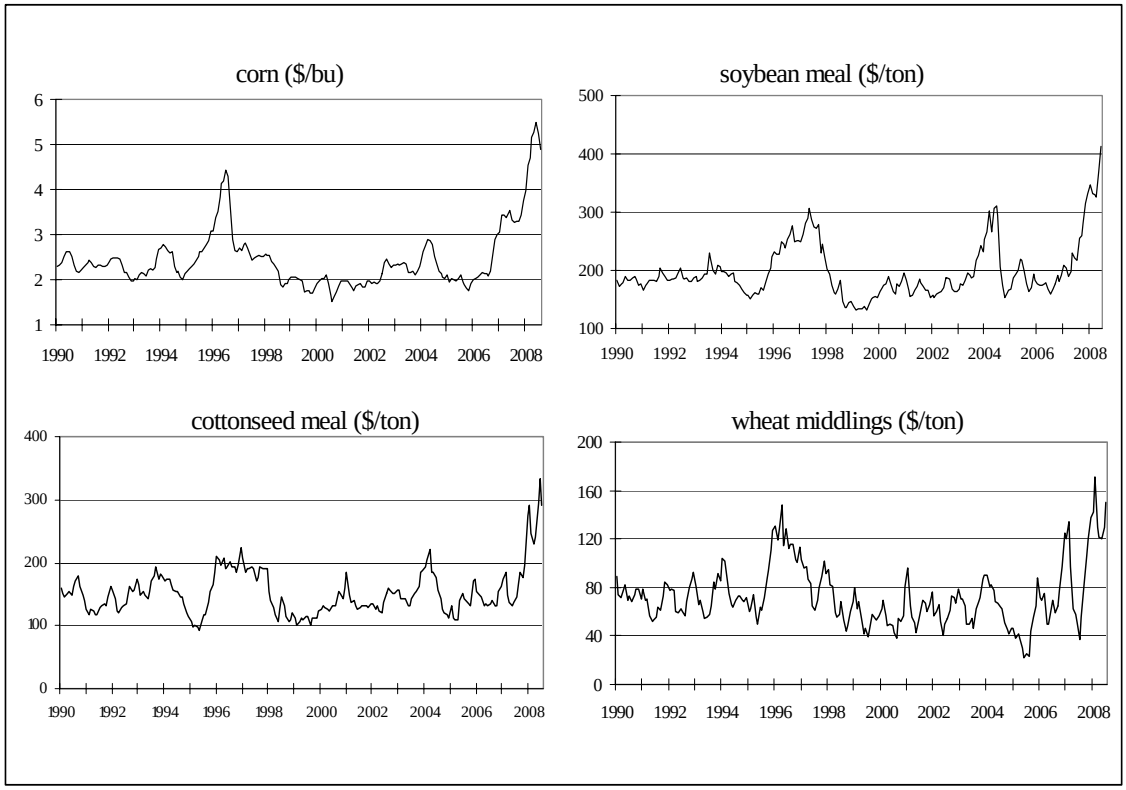

Figure 2. Price of Catfish Feed Ingredient: 1990-2008 (Source: ERS)

3. Empirical Methods

Two markets are considered in this study, the catfish feed market and the catfish market at the farm level. Given the supply and demand for feed, various factors are considered as determinants of catfish feed prices. These include: the price of catfish at the farm level, corn prices, soybean meal prices, cottonseed meal price, and energy prices. Preliminary analysis indicated that wheat prices were less of a factor once the other grains were considered. Corn, soybean meal and cottonseed meal prices should positively affect catfish feed prices since these are inputs in the production of catfish feed. Given that feed is demanded by catfish farmers, the price of catfish at the farm level should

also positively impact feed prices. Because energy is an input in farm and feed production, it is not known for sure whether energy price positively or negatively impact feed prices. The general reduced form feed price equation is as follows (variable names are given in the Table 1):

(1) $$Pfeed = \phi(Pf, Pco, Pso, Pct, Pe)$$

For the catfish farm price reduced form equation, three variables are considered: catfish feed prices, processed catfish prices, and energy prices. Feed and energy prices are inputs in catfish production. Feed prices should have a positive impact on farm prices. Given that processors demand catfish at the farm level, the price of processed catfish price should also have a positive impact on farm prices. Because energy is an input for both farmers and processors, it is not known for sure whether the energy price positively or negatively impacts the price of catfish at the farm level. The reduced form farm price equation is specified as follows (variable names are given in the Table 1):

(2) $$Pf = \varphi(Pfeed, Pp, Pe)$$

Table 1. Variable Description

Pf	Catfish price (farm level)
Pfeed	Catfish feed price
Pe	Energy price
Pco	Price of corn
Pso	Price of soybean meal
Pct	Price of cotton seed
Pp	Price of processed catfish

Linear functional forms are assumed for equations (1) and (2). Because of the time series properties of the data, and to account for dynamic adjustments in supply and demand, the ARDL model is used in estimation. Perasan et al. (2001) show that the error correction form of the ARDL model can be used to determine if there is a long-run relationship between a dependent variable and a set of regressors, when it is not know with certainty whether the underlying regressors are trend or first-difference stationary.

Following the methodology of Perasan et al. (2001) and the empirical examples of Baek and Koo (2007), and Bahmani (2008), the reduced form equations are specified as follows:

$$\text{(3)} \quad \Delta \ln Pfeed_t = \beta + \sum_{i=1}^{n1} \beta_{1i} \Delta \ln Pfeed_{t-i} + \sum_{i=0}^{n2} \beta_{2i} \Delta \ln Pf_{t-i} + \sum_{i=0}^{n3} \beta_{3i} \Delta \ln Pco_{t-i}$$
$$+ \sum_{i=0}^{n4} \beta_{4i} \Delta \ln Pso_{t-i} + \sum_{i=0}^{n5} \beta_{5i} \Delta \ln Pct_{t-i} + \sum_{i=0}^{n6} \beta_{6i} \Delta \ln Pe_{t-i}$$
$$+ \delta_1 \ln Pfeed_{t-1} + \delta_2 \ln Pf_{t-1} + \delta_3 \ln Pco_{t-1} + \delta_4 \ln Pso_{t-1}$$
$$+ \delta_5 \ln Pct_{t-1} + \delta_6 \ln Pe_{t-1} + \varepsilon_t$$

$$\text{(4)} \quad \Delta \ln Pf_t = \vartheta + \sum_{i=1}^{m1} \vartheta_{1i} \Delta \ln Pf_{t-i} + \sum_{i=0}^{m2} \vartheta_{2i} \Delta \ln Pp_{t-i} + \sum_{i=0}^{m3} \vartheta_{3i} \Delta \ln Pfeed_{t-i}$$
$$+ \sum_{i=0}^{m4} \vartheta_{4i} \Delta \ln Pe_{t-i} + \gamma_1 \ln Pf_{t-1} + \gamma_2 \ln Pp_{t-1} + \gamma_3 \ln Pfeed_{t-1} + \gamma_4 \ln Pe_{t-1} + \mu_t$$

The parameters (β_i's and ϑ_i's) measure the short-run dynamics between the dependent variable and the regressors and the δ's and the γ's represent the long-run relationship where the levels relationship make up the short-run error correction. ε and μ are random disturbance terms where $\varepsilon \sim N(0, \sigma_\varepsilon^2)$ and $\mu \sim N(0, \sigma_\mu^2)$.

In order to determine if there is a long-run relationship in levels (cointegration) the following hypotheses are tested:

Ho: $\delta_1 = \delta_2 = \delta_3 = \delta_5 = \delta_6 = 0$

Ho: $\gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = 0$.

If these hypotheses hold true then the variables are not cointegrated. The F-statistics for the above restrictions do not follow the typical F distribution (Pesaran et al., 2001). Pesaran et al. (2001) give the critical values to determine the joint significance of the level variables where they derived upper bound critical values when all variables are first-difference stationary I(1) for significance levels of 0.10, 0.05, 0.025, and 0.010. They are also derived lower bound critical values for the same significance levels when the variables are I(0). A long-run relationship is established when the F-statistic for no cointegration exceeds the upper bound critical value.

4. Empirical Results

Monthly data was used to estimate equations (3) and (4). The time period for the data was from January 1996 to December 2007. Data sources include: the National Agricultural Statistics Service (NASS), Bureau of Labor Statistics (BLS), and USDA Economic Research Services (ERS). Catfish feed prices in $/ton, catfish farm prices in $/lb and catfish prices at the processor level in $/lb were provided by NASS. The price of #2 yellow corn ($/bushel), 49% protein soybean meal ($/ton), and cottonseed meal ($/ton) were provided by ERS. BLS provided the energy price index. Because the catfish production cycle is around 18 months, feed prices were lagged 18 months when estimating equation (4).

The F-test for cointegration is sensitive to the number of lags imposed on the differenced variables. Following Pesaran et al. (2001), the Akaike's information criterion (AIC) was used in selecting the optimum lag length.

Serial correlation of the error terms was also considered. The final equations were as follows (estimation results are reported in Tables 2 and 3):

$$(5)\qquad \Delta \ln Pfeed_t = \beta + \beta_{1i}\Delta \ln Pfeed_{t-i} + \sum_{i=1}^{2}\beta_{2i}\Delta \ln Pf_{t-i} + \sum_{i=0}^{1}\beta_{3i}\Delta \ln Pco_{t-i}$$
$$+\beta_4\Delta \ln Pso_t + \beta_5\Delta \ln Pct_{t-1} + \beta_6\Delta \ln Pe_{t-1} + \delta_1 \ln Pfeed_{t-1} + \delta_2 \ln Pf_{t-1}$$
$$+\delta_3 \ln Pco_{t-1} + \delta_4 \ln Pso_{t-1} + \delta_5 \ln Pct_{t-1} + \delta_6 \ln Pe_{t-1} + \varepsilon_t$$

$$(6)\qquad \Delta \ln Pf_t = \vartheta + \vartheta_1\Delta \ln Pf_{t-1} + \sum_{i=0}^{1}\vartheta_{2i}\Delta \ln Pp_{t-i} + \vartheta_3\Delta \ln Pfeed_t^* + \vartheta_4\Delta \ln Pe_t$$
$$+\gamma_1 \ln Pf_{t-1} + \gamma_2 \ln Pp_{t-1} + \gamma_3 \ln Pfeed_{t-1} + \gamma_4 \ln Pe_{t-1} + \mu_t .$$

Note that $Pfeed_t^* = Pfeed_{t-18}$. Feed price results are presented in Table 2. Overall the model was a good fit. See the diagnostics in Table 2. The short-run relationships between the feed price and the regressors were for the most part significant at the 1% and 5% levels. The short-run results show that a 1% increase in the catfish farm price (lagged one-month) results in a 0.258% increase in the feed price, and a percentage increase in the corn price (lagged one-month) and current soybean price results in a feed price increase of 0.135% and 0.128%, respectively. For the cotton price, current and lagged, the feed price increases by 0.120% and 0.094%, respectively. In the short-run, the affects of energy was negative (-0.94).

In the long-run, the grain prices as well as the energy price were significant at the 5% significance level. The F-statistic for testing the existence of a long-run relationship was 4.24. This exceeded the 5% upper bound critical value of 3.61 (see Pesaran et al., 2001) suggesting that the null hypothesis of no cointegration should be rejected. In the long-run, a 1% increase in corn and soybean prices causes feed prices to increase by 0.263% and 0.292 %, respectively.

Table 2. Estimation Results for Equation (5): Catfish Feed Prices

Short-run coefficient estimates			
	Lag Order		
	0	1	2
$\Delta \ln Pfeed$		-0.159** (0.03)	
$\Delta \ln Pf$		-0.099 (0.39)	0.258** (0.03)
$\Delta \ln Pco$		0.134*** (0.00)	
$\Delta \ln Pso$	0.128*** (0.00)		
$\Delta \ln Pct$	0.120*** (0.00)	0.094*** (0.00)	
$\Delta \ln Pe$		-0.094** (0.06)	

Long-run coefficient estimates and regression diagnostics						
Constant	$\ln Pf$	$\ln Pco$	$\ln Pso$	$\ln Pct$	$\ln Pe$	EC_{t-1}
2.644*** (0.00)	-0.030 (0.49)	0.263*** (0.00)	0.292*** (0.00)	0.087** (0.04)	0.120*** (0.00)	-0.193*** (0.00)
F^{LR} = 4.24	$\overline{R}^2$ =0.51	LM 0.484 [0.486]	RESET 0.485 [0.800]			

Notes: *** indicates significance at the 1% level; ** 5% significance level; * 10% significance level. The upper-bound critical value of the F-statistic at the 5% level of significance is 3.61 (see Pesaran et al., 2001). *EC* is the error correction term. LM is the Lagrange multiplier test for serial correlation, which has a χ^2 distribution (the p-value is in brackets). RESET is Ramsey's specification test, which also has a χ^2 distribution (the p-value is in brackets).

Catfish price results are presented in Table 3. Overall the model was a good fit. See the diagnostics in Table 3. In the short run, the catfish farm price lagged one-month, current and lagged price at the processor level, and the current feed price were significant at the 5% significance level. Results show that a percentage increase in the feed price and processed catfish price causes

the farm price to increase by 0.106% and 0.850%, respectively. The energy price had a negative impact in the short run (-0.137).

Table 3. Estimation Results for Equation (6): Catfish Farm Prices

Short-run coefficient estimates				
	Lag Order			
	0	1		
$\Delta \ln Pf$		0.319*** (0.00)		
$\Delta \ln Pp$	0.850*** (0.00)	0.301** (0.02)		
$\Delta \ln Pfeed$	0.106** (0.01)			
$\Delta \ln Pe$	-0.137* (0.053)			
Long-run coefficient estimates and diagnostics				
Constant	$\ln Pp$	$\ln Pfeed$	$\ln Pe$	EC_{t-1}
-1.594*** (0.00)	1.702*** (0.00)	0.211*** (0.00)	0.054*** (0.00)	-0.241*** (0.00)
F^{LR} =5.61	$\overline{R^2}$ =0.64	LM 1.911 [0.167]	RESET 2.279 [0.134]	

Notes: *** indicates significance at the 1% level; ** 5% significance level; * 10% significance level. The upper-bound critical value of the F-statistic at the 5% level of significance is 4.01 (see Pesaran et al., 2001). *EC* is the error correction term. LM is the Lagrange multiplier test for serial correlation, which has a χ^2 distribution (the p-value is in brackets). RESET is Ramsey's specification test, which also has a χ^2 distribution (the p-value is in brackets).

In the long-run, the processed catfish price, feed price and energy price were all significant at 1% significance level. The F-statistic for testing the existence of a long-run relationship was 5.61. This exceeded the 5% upper bound critical value of 4.01 (see Pesaran et al., 2001) suggesting that the null hypothesis of no cointegration should be rejected. In the long-run, a percentage increase in the processor price causes the catfish farm price to increase by 1.702%, a percentage increase in the feed price causes the farm

price to increase by 0.211%, and a percentage increase in the energy price causes the farm price to decrease by -0.241%.

5. Summary and Ethanol Implications

In this study, we estimated catfish feed and farm price reduced form equations. Of particular importance was the impact of the recent increase in grain prices induced by ethanol production on feed cost and farm prices. This relationship was examined using an autoregressive distributed lag (ARDL) model. Results show that a 1% increase in corn prices caused a 0.134% and 0.263% increase in feed prices in the short- and long-run, respectively. Catfish farm prices increased by 0.106% (short-run) and 0.211% (long-run) given a 1% increase in feed prices.

Between 2004 and 2008, corn prices increased from $2 to $6 per bushels. Taheripour and Tyner (2008) state that of the total increase 25% was due to US ethanol subsidies and 75% was due to the increase in the price of crude oil. Given the $1 increase in corn prices (50%), this should result in a feed price increase of 13% and a farm price increase of 2.7% in the long-run. Park and Fortenbery (2007) found that for every percentage increase in ethanol production, corn prices increased by 0.16 % in the short run. From this we conclude that a 100% increase in ethanol production will cause catfish feed prices to increase by 4.21% in the long run, and catfish farm prices to increase by 0.89%.

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