THE IMPACT OF FEED COST ON U.S. POULTRY PRODUCTION: IMPLICATIONS FOR THE IMPACT OF INCREASED ETHANOL PRODUCTION

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1. Introduction

Increased ethanol production from corn grain has created many new opportunities and challenges for the United States agricultural sector. Ethanol production increased from 1.6 billion gallons in 2000, to approximately 5 billion gallons in 2006, and based on current capacity and new construction, could reach 11.4 billion gallons in 2008-2009. In order to meet the demand for corn from ethanol production, it is estimated that between 7.8 and 9.7 million additional corn acres will be needed (Collins, 2007). Corn prices are being bid up in an effort to purchase these acres from other areas of production. The resulting increase in corn prices has created a great deal of concern in the livestock, and particularly the poultry, industry. Given the concerns of higher feed costs, the objective of this study is to determine the sensitivity of U.S. broiler production to changes in corn prices. Specific objectives of this study are: (1) to econometrically estimate U.S. broiler supply to asses the impact of feed cost on U.S. broiler production, (2) to estimate the elasticity of broiler production with respect to feed cost and corn prices, and (3) to project future U.S. broiler production given increases in corn prices resulting from increased demand due an expansion of the ethanol industry.

2. Background

Historically, commodity prices are lower in harvest months and following large crop seasons. Commodity markets are typically driven by supply; however, the increase in ethanol production has created a demand driven market for corn. Unlike supply driven price spikes, such as a weather supply shock, ethanol demand may be permanent and could have prices at current levels for a lengthy period of time. On the Chicago Board of Trade, the December 2007 futures contract recently traded above $4.00, or double what is was this time last year following the third largest corn crop in U.S. history (Laws, 2007). This was the second highest corn price in the last 40 years. In the 1995-1996 crop year, first quarter prices averaged near $3.50 before climbing near $5.00 in the third quarter; however, prices in the fourth quarter retreated back to the $3.00 range (Pedersen, 2007). In contrast, the record corn crop of 2004 (11.807 bushels) caused corn prices to fall from $3.40 in April of that year to $1.94 in January 2005. **[See Figure 1.]**

Figure 1 illustrates the poultry industries response to the increased corn price. The crop year 1995-1996 saw ready to cook production increase 5.8 percent from the1994-1995 crop year. Ready to cook production growth slowed to 3.1 percent in 1996-1997, and in 1997-1998 increased again to 5.7 percent (Pedersen, 2007). While growth slowed following the increase in corn prices, it was still positive and lasted for a short period of time. This further illustrates that supply shocks disrupt markets for short periods of time; however, increased corn prices from ethanol demand could have longer lasting effects.

USDA Chief Economist Keith Collins (2007), in an address to the American Farm Bureau, stated that at ethanol prices of $1.85, and current co-product prices, ethanol producers could pay $4.50 a bushel and cover variable costs. While ethanol producers are able to remain profitable at these corn prices, concern is being raised in livestock markets, particularly the poultry industry. Richard Cogdill of Pilgrim’s Pride Corporation estimates that a penny increase in the cost of corn adds an additional $2 million a year to its expenses for feed. Analysts have stated that Tyson Foods, the largest poultry producer in the United States, profit loss could be $0.05 a share for every $0.10 rise in per-bushel corn prices (Wilson, 2006). William P. Roenigk, chief economist for the National Chicken Council (NCC), estimates that “ethanol demand has increased the price of chicken by six cents per pound wholesale.”(Worldpoultry, 2007)

The National Corn Growers Association (NCGA) argues that ethanol production does not divert corn away from food and feed markets, nor does it cause increases in consumer food prices (NCGA, 2006). For every 56-pound bushel of corn used in the dry grind ethanol production process, 18 pounds of distillers grains (DDGS) are produced. The DDGS are the by-product of the corn after the starch has been removed, and contain high amounts of protein. While rudiment animals, such as beef and dairy cattle, can substitute DDGS for corn feed, it is much more difficult for DDGS to replace corn rations for poultry and swine. Estimates are reported that broiler feeds can consist of up to 10 percent DDGS; however, this amount may be optimistic.

DDGS present several problems when looking at poultry diets. Inclusion at a rate of greater than 5 percent can lead to passage of undigested feed due to the high fiber content[1]. In addition, DDGS can have highly variable nutrient content, which can lead to amino acid imbalance. Unlike soybean meal, which consistently maintains nutrient balance, DDGS would not be included in the diet without nutrient analysis. This would represent an additional cost on each shipment prior to use. Recently constructed ethanol plants are using new technology and improved quality control procedures to produce higher quality DDGS (Gibson et al, 2006). Additionally, DDGS become compacted in rail cars, barges, and trucks making unloading difficult and time consuming. To alleviate some of the flowability problems, mills have tried pelletizing the DDGS; however, trials so far have been unsuccessful. Currently, DDGS prices are 115 percent higher than corn prices, and need to be around 80 percent to become feasible. If

[1] This statement is from personal communication with Dr. Tim Chamblee, Department of Poultry Science, Mississippi State University on February 13, 2007.

DDGS is included in poultry diets, the adding of fat is necessary to replace the energy of the displaced corn which is expensive and can cause rancidity problems (Batal, 2007).

3. Empirical Model

Following Theil (1980, p. 38), the differential output supply equation for a single output producer with *n* inputs can be specified as follows:

(1) $$d(\log Q) = \frac{\psi}{\gamma - \psi}\left[d(\log p) - \sum_{i=1}^{n} \theta_i d(\log w_i) \right]$$

where *Q* represents farm output, *p* is the output price, and the w_i's are input prices. ψ is a positive scalar and may be regarded as a measure of the curvature of the logarithmic cost function and γ is the elasticity of total cost with respect to output. θ_i is the marginal share of the *i*th input in total cost (Laitinen, 1980, pp. 42-43; Theil 1980, pp. 32-33).[2]

Assuming ψ, γ and θ_i are constant, the finite version of equation (1) for a broiler-producing firm is expressed as follows:

(2) $$\Delta Q_t = \pi_0 + \pi_1 \Delta p_{t-1} + \pi_2 \Delta fp_{t-1} + \pi_3 \Delta w_{t-1} + \pi_4 \Delta h_{t-1} + \varepsilon_t \ .$$

For any variable *x*, $\Delta x_t = \log(x_t) - \log(x_{t-4})$. *Q* is total U.S. broiler production in thousands of pounds. Broiler prices in cents per pound are represented by *p*, and *fp* is the broiler feed-price ratio. The variable *w* represents farm wages and *h* is the number of chicks hatched which measures the number live chicks taken from incubators.[3] ε_t is a random disturbance term.

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[2] $\theta_i = \partial(w_i x_i)/\partial C$ where x_i is the quantity of the *i*th input and *C* is total cost.

[3] The four-period difference is used to correct for seasonality (Kmenta, 1986, 325–326). The original model included corn and soybean prices instead of the feed-price ratio. Preliminary estimation results indicated that corn and soybean prices were insignificant and that the feed-price ratio was a better fit.

Given a production period of approximately two months, the independent variables are lagged one period (1 quarter). Equation (1) states that the log change in broiler production is a function of the log change in output prices, feed-price ratio, wages, and chicks hatched the pervious quarter. The supply specification in Theil (1980) indicates that the output supply for a profit maximizing firm should be expressed as a function of output and input prices. However, given that the USDA discontinued reporting monthly and quarterly broiler chick prices in 1994, and that broiler producers often contract with processors for chicks at no cost, we include the quantity of chicks hatch in the supply equation as oppose to chick prices. To account for the indirect impact of feed cost on production through the number of chicks hatched, the derived demand for hatched chicks was estimated as well. The derived demand equation, also expressed in differential form is

(3) $$\Delta h_t = \beta_0 + \beta_1 \Delta fp_t + \beta_2 \Delta w_t + u_t \ .$$

Equation (3) state that the number of chicks hatched in period *t* is a function of the feed-price ratio and farm wages. All variables in equation (3) are in four-period log changes as well. u_t is a random disturbance term. Given limited data on feed quantities and the quantities of other productive inputs, this analysis was limited to the derived demand for chicks only.

Substituting equation (3) into equation (2), the elasticity of broiler output with respect to feed cost is

(4) $$\eta_{Q,feed} = \frac{d \log(Q)}{d \log(fp)} = \pi_2 + \pi_4 \beta_1$$

Letting feed cost be the sum of corn cost and other feed cost, it is easily shown that

$$d \log(feed) = d \log(corn)(corn/feed) + d \log(other)(other/feed) \ .$$

This implies that the output elasticity with respect to corn cost is

(5) $$\eta_{Q,corn} = \frac{d\log(Q)}{d\log(corn)} = (\pi_2 + \pi_4\,\beta_1)\,\frac{corn}{feed}\,.$$

From equation (5) the impact of changes in corn prices on U.S. broiler production can be simulated with the following equation,

(6) $$Q_t = \left(\eta_{Q,corn}\left[\frac{corn_t - corn_{t-1}}{corn_{t-1}}\right]\right)Q_{t-1} + Q_{t-1}\,.$$

4. Data and Variable Statistics

The data used to estimate equation (2) and equation (3) was compiled by the USDA, National Agricultural Statistical Service (NASS) and obtained from the USDA Economic Research Service (ERS) website. We use quarterly data from 1987 through 2004. In 1987, ERS changed their estimation procedure for poultry feed. Poultry feed costs prior to 1987 were actual feed costs. Since 1987, feed costs were calculated as 70 percent corn and 30 percent soybean meal. The variables in the model included U.S. broiler production, the broiler feed-price ratio, number of chicks hatched, and U.S. broiler prices. Average farm wages were obtain from the Bureau of Labor Statistics.

Descriptive statistics for the dependent and independent variables are provided in Table 1. From 1987 through 2004 U.S. broiler production averaged 8.56 billion pounds. During this period, maximum production was 12 billion pounds and minimum production was 5.15 billion pounds. U.S. broiler prices ranged from a high of 50 cents per pound to a low of 25.3 cents per pound, and averaged 35.2 cents during the data period. The feed-price ratio averaged 4.2 during the data period and reached a maximum of 7.8 and was as low as 2.6. Hourly earnings for farm labor during the data period averaged \$6.56/hour. The maximum and minimum were \$8.91/hour and \$4.27/hour respectively. The number of commercial chicks hatched during the data period averaged nearly 2 billion birds. The maximum and minimum were 2.4 billion and 1.3 billion birds respectively. **[See Table 1.]**

5. Empirical Results

Using quarterly data from 1987 to 2004, equation (2) and equation (3) were estimated using the LSQ and AR(1) procedures respectively in TSP version 5.0. Estimation results for the U.S. broiler output supply and the derived demand for hatched chicks are presented in Table 2. All of the independent variables in the U.S. broiler supply equation were significant by at least the 5 percent significance level and all variables were consistent with theoretical expectations. Given the structure of equation (2), each variable estimate is an elasticity measuring the responsiveness of output to that independent variable. As expected, the number of chicks hatched had a relatively large impact on total production. A percentage increase in the number of chicks hatched, increased U.S. broiler production by 0.77 percent. Farm wages had the next largest impact (- 0.196). The impact of feed costs on U.S. broiler production was -0.036 indicating that for every percent increase in the feed-price ratio U.S. broiler production decreased by 0.036 percent. The output price estimate (own-price supply elasticity) indicated that for every percentage increase in U.S. broiler prices, broiler production increased by 0.031. With the exception of farm wages, derived demand estimates for chicks also conformed to theoretical expectations; however, the impact of farm wages was insignificant. The impact of the feed-price ratio on the number hatched chicks was -0.0317 **[See Table 2.]**

Elasticity estimates based on equation (4) and equation (5) were -0.060 and -0.042 respectively. We assume that corn is 70 percent of total feed. These indicate that a one-percent increase in the feed cost decreases U.S. broiler production by 0.06 percent and a one-percent increase in corn cost decreases U.S. broiler production by 0.042 percent. Eales and Unnevehr (1993) provide some explanation why the impact of corn and feed cost on U.S. broiler production is highly inelastic. The supply of poultry might also be represented by its relationship with competing meats. Primary poultry substitutes in the meat category are beef and pork. The elasticities of poultry, beef, and pork, suggest that small percentage changes in poultry prices create very small changes in the quantity of beef and pork demanded. However, small percentage changes in beef and pork prices create much larger percentage increases in the demand for poultry. This suggests that when all meat prices increase, consumers substitute poultry for beef and pork products. Given that corn is a major component of feed for all meats, we can assume that corn prices will affect the supply of beef, pork and poultry, resulting in increased prices for all meats, which could have a relative favorable impact on poultry consumption (Eales and Unnevehr, 1993). **[See Table 3.]**

Using the equation (6) we project the impact of increased corn prices on U.S. poultry production. We used average broiler production and the average corn price for 2004 which was 11.67 billion lbs and $2.50 per bushel respectively as our baseline. Given that ethanol producers will still cover variable production cost if corn prices increase to $4.50 per bushel, we simulate the impact of corn prices increasing from the baseline average of $2.50 to $4.50. We assume $0.20 increments to track the incremental impact on U.S. poultry production. Results are presented in Table 4. This analysis is limited in that is does not consider the impact of corn prices on beef and pork prices which is expected to have a positive impact on poultry consumption/production, however this may be reflected in the relative small response of broiler production to changes in corn prices. Results suggest that if corn prices increased from $2.50 to $4.50, U.S. broiler production would decrease from 11.67 billion lbs to 11.38 billion lbs, an overall decrease of 290 million lbs or 3 percent. Using 45 cents per lb as the output price (average price for 2004), total industry value for the baseline period is $5.3 billion and the decrease in production represents a loss of $133.2 million for the industry. **[See Table 4.]**

6. Summary and Conclusions

This study examined poultry supply response to changes in feed costs, or corn prices. Since 1987 the poultry industry has experienced tremendous growth, even in times of higher corn prices. Renewable energy has created a new agricultural environment that is rapidly changing.
Given the concerns of higher feed costs due to increase ethanol production, the objective of this study was to determine the sensitivity of U.S. broiler production to changes in corn prices. Elasticity estimates indicated that percentage increases in feed cost decreased U.S. broiler production by 0.06 percent and percentage increases in corn cost decreased U.S. broiler production by 0.042 percent. Simulation results project that if corn prices increased from $2.50 to $4.50, U.S. broiler production would decrease from 11.67 billion lbs to 11.38 billion lbs, an overall decrease of 3 percent, which represents a loss of $133.2 million for the industry.

Given results, assumptions can be made as to the relatively small decrease in broiler supply. Among these are poultry relationships with other meats and contractual agreements. Given that corn is a major component of feeds for all meats, corn prices will affect the supply of beef and pork as well as poultry. Meat prices will likely increase, which should increase the consumption of poultry relative to beef and pork. Vertical integration may also have an effect on poultry supply. Poultry processors often contract with many grower operators. The integrator supplies the chicks and feed, among other aspects of production, to the grower. These companies have invested much time and money into research that has created a very efficient production process. Since 1920, mortality rates have decreased from 18 percent to 4 percent in 2005 (NCC, 2006). The increase in productivity may likely have keep production strong in the face of significant increases in corn prices. This suggest that the results of this study should be taken with some caution given that producers may be more responsive to present changes corn prices resulting from ethanol production. Therefore the impact of corn prices on broiler production may be greater than results suggest.

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Table 1. Descriptive statistics for all variables

Symbol	Variable description	Mean	Std. Dev.	Minimum	Maximum
Q	U.S. broiler production in lbs (thousands)	8.56E+06	1.98E+06	5.15E+06	1.20E+07
p	U.S. broiler price in cents per lb	35.17	4.69	25.30	50.00
fp	Feed-price ratio	4.19	1.15	2.60	7.80
w	Average hourly farm wages (dollars per hour)	$ 6.56	1.44	4.27	8.91
h	Number of chicks hatched (thousands)	1.92E+06	3.20E+05	1.30E+06	2.39E+06

Table 2. Output-supply and derived demand estimation results

<u>U.S. Broiler Supply</u>

$$\widehat{\Delta Q}_t = 0.0287 + 0.0311\ \Delta p_{t-1} - 0.0358\ \Delta(f_t / p_t)_{t-1} - 0.1962\ \Delta w_{t-1} + 0.7735\ \Delta h_{t-1}$$
$$(.005)^{***}\quad (.014)^{**}\qquad (.015)^{**}\qquad (.079)^{**}\qquad (.105)^{***}$$

$R^2 = .52, \quad DW = 2.222$

<u>Chick Demand</u>

$$\widehat{\Delta h}_t = 0.0328 - 0.0317\ \Delta(f / p)_t + 0.0366\ \Delta w_t$$
$$(.001)^{***}\quad (.016)^{**}\qquad (.091)$$

$R^2 = .55, \quad DW = 2.058 \quad \rho = 0.740\ (.080)^{***}$

<u>Elasticity Estimates</u>

$\eta_{Q,feed}$ = -0.060 (.012)

$\eta_{Q,corn}$ = -0.042 (.009)

Standard errors are in parenthesis.
*** 0.01 significance
** 0.05 significance

Table 3. Own and cross price elasticities of demand for poultry, beef, and pork

	Poultry	Beef	Pork
Poultry	-0.233	0.385	.041
Beef	0.070	-0.850	-0.045
Pork	0.013	-0.107	-1.234

Eales and Unnevehr (1993)

Table 4. Projected impact of corn prices on U.S. broiler production

Corn Price	U.S. Broiler Production 1,000 lbs	Percentage Change	Overall Percentage Change	Estimated Industry Loss
$ 2.50	**11,674,500**	**(Baseline)**		
$ 2.70	11,634,968	-0.34%		
$ 2.90	11,598,492	-0.31%		
$ 3.10	11,564,640	-0.29%		
$ 3.30	11,533,066	-0.27%		
$ 3.50	11,503,489	-0.26%		
$ 3.70	11,475,674	-0.24%		
$ 3.90	11,449,428	-0.23%		
$ 4.10	11,424,585	-0.22%		
$ 4.30	11,401,007	-0.21%		
$ 4.50	11,378,572	-0.20%	**-3%**	**$ (133,167,474.07)**

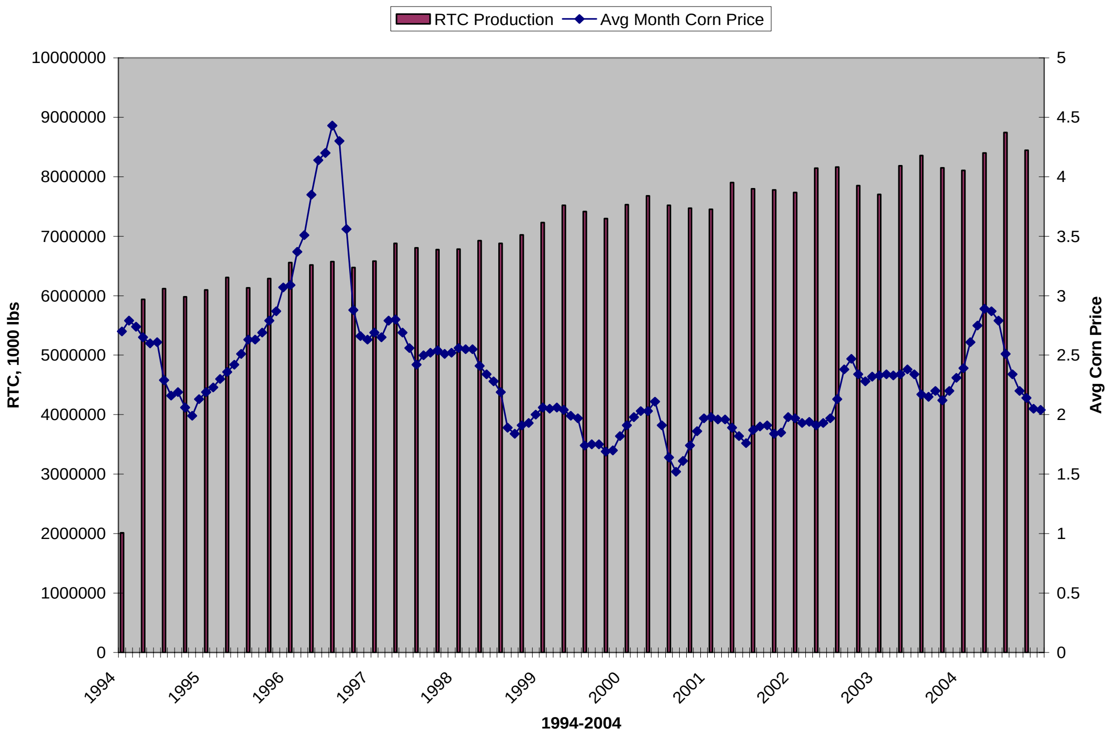

Figure 1. Quarterly ready-to-cook poultry production and average monthly corn prices from 1994 to 2004