U.S. BROILER, TURKEY AND TOTAL POULTRY SUPPLY RESPONSE TO CORN FEED PRICES

Ahmed Hussein

Abstract

Corn constitutes about 60 % of the normal poultry diet, and the remaining ingredients are soybean meal(Leeson and Summers 2005). The feed cost represents about 70% of the operation cost shares in poultry production. So any increase in corn feed prices could potentially reduce the profit margin for poultry growers and consequently a reduction in the quantity of poultry produced and a higher price for poultry meat at the retail level. Most of the recent corn price spikes in the U.S has been partly due to ethanol production which consumes about 30% of U.S corn. This paper deploys Nerlovian partial adjustment model for broiler, turkey and total poultry production in the U.S. The previous period's corn feed price elasticity of demand is greater in the long-run compared to the short-run across broiler and total poultry production. Meanwhile, turkey production shows higher adjustment speeds but lower short and long-run corn feed price elasticity of demand.

Key words: Nerlove Model, corn price, poultry production.

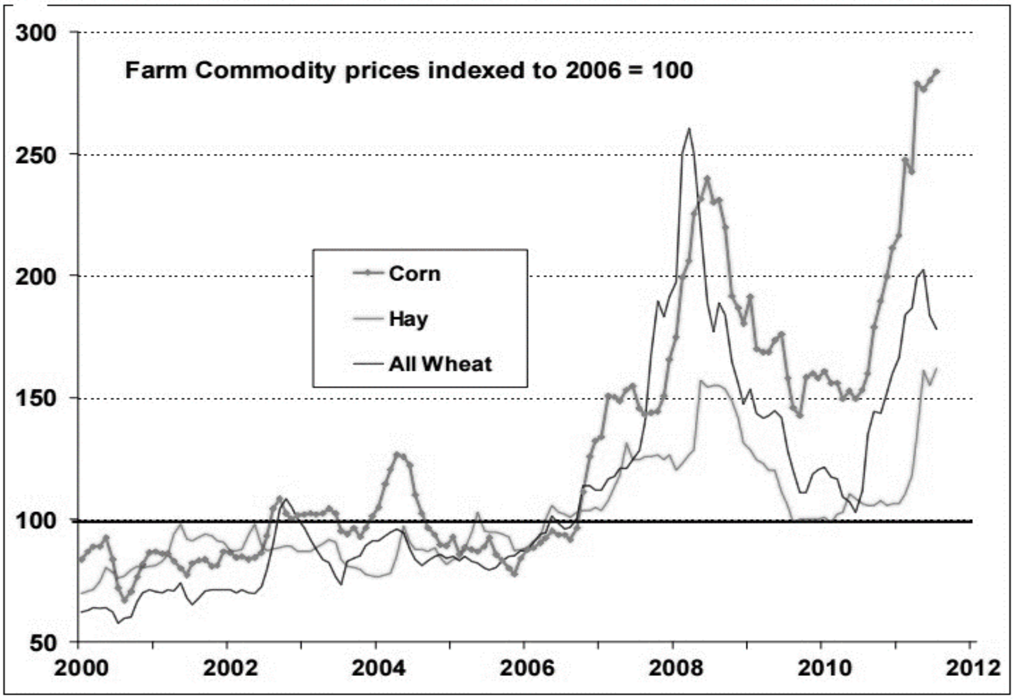
Introduction

The price increase of feed grains in recent years has put a lot of pressure on the livestock and poultry sectors in the U.S. due to tight supply and growing demand for corn ethanol. In the poultry industry, feed grains account for approximately 70% of operation expenditures. Hogs and poultry feed are more heavily dependent on corn compared to fed cattle, except when cattle are being finished (Schnepf 2011). Swine and poultry, are limited in diet choices compared to other livestock species which can utilize forages or ethanol byproduct based rations (Stillman, Haley, and Mathews 2009). This ongoing surge in the price of feed grain is due to increase in the price of corn and gradually have contributed to a reduction in profit margins for poultry producers. The small profit margin will make the producers decrease the number of poultry they produce. Thus, potentially higher retail prices and less overall poultry production. While some economist believe that high feed prices can be profitable for the processor, this can be true only in a situation when the production is dropping. As poultry production declines the price of poultry derived products will rise inversely at the retail level (Donohue and Cunningham 2009). In September 2006 the cost of production cost per pound of live weight for broilers increased from 0.25$ to 0.45$ in 2008.

Likewise, per pound, meat production for turkey rose from 0.35$ to 0.58$ from 2006 to 2008, respectively(Donohue and Cunningham 2009).

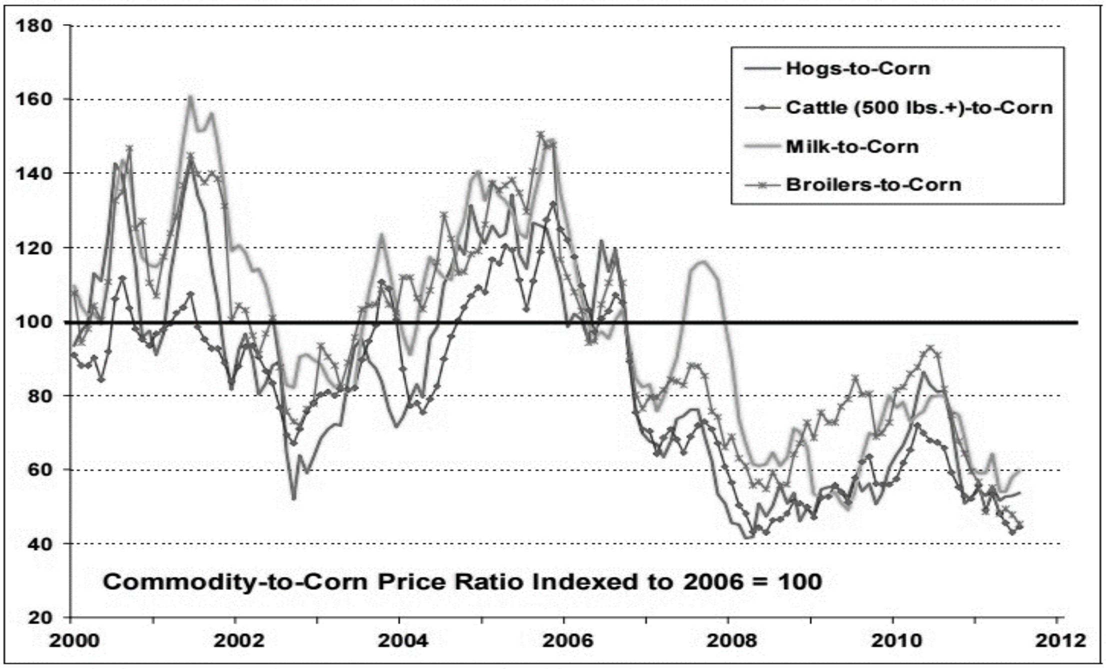
The price increase of feed grain in recent years have put a lot of pressure on livestock and poultry sector in the U.S. due to tight supply and growing demand for corn ethanol. Poultry production relies heavily on corn for feed, nearly 60% of the poultry diets are composed of corn. There is not much feed substitute for poultry and hogs since they have a monogastric digestive system. Swine and poultry there are not as many alternative diets as livestock that can feed on forages or cellulose byproducts from ethanol production. Also, poultry growers look for low-cost feed since the biggest share of poultry operation cost is for feed which is about 70% of the total cost (Schnepf 2011). As the price of the feed cost increases the profit markings decline for livestock and poultry producers, figures 1 and 2 shows the recent commodity price index for some grains and commodity to corn-feed ratio from 2000-2012. This makes the farmers keep a lower future herd of animals, and ultimately this will lead to higher retail prices for beef, poultry, eggs and meat. The relative high grain prices caused a decline in the share value of livestock and poultry sector compare to crop sector from 51% during 2000-2005 to 43% in 2008 decrease in U.S agricultural cash receipts (ERS, USDA) figure3.

Figure 1 U.S. Monthly Farm Prices Received for Corn, Wheat, and Hay Since 2000



Source: Calculations by CRS using data from NASS, USDA, July 31, 2011.

Figure 2 Livestock-to-Corn Price Ratios Have Trended Downward Since 2006

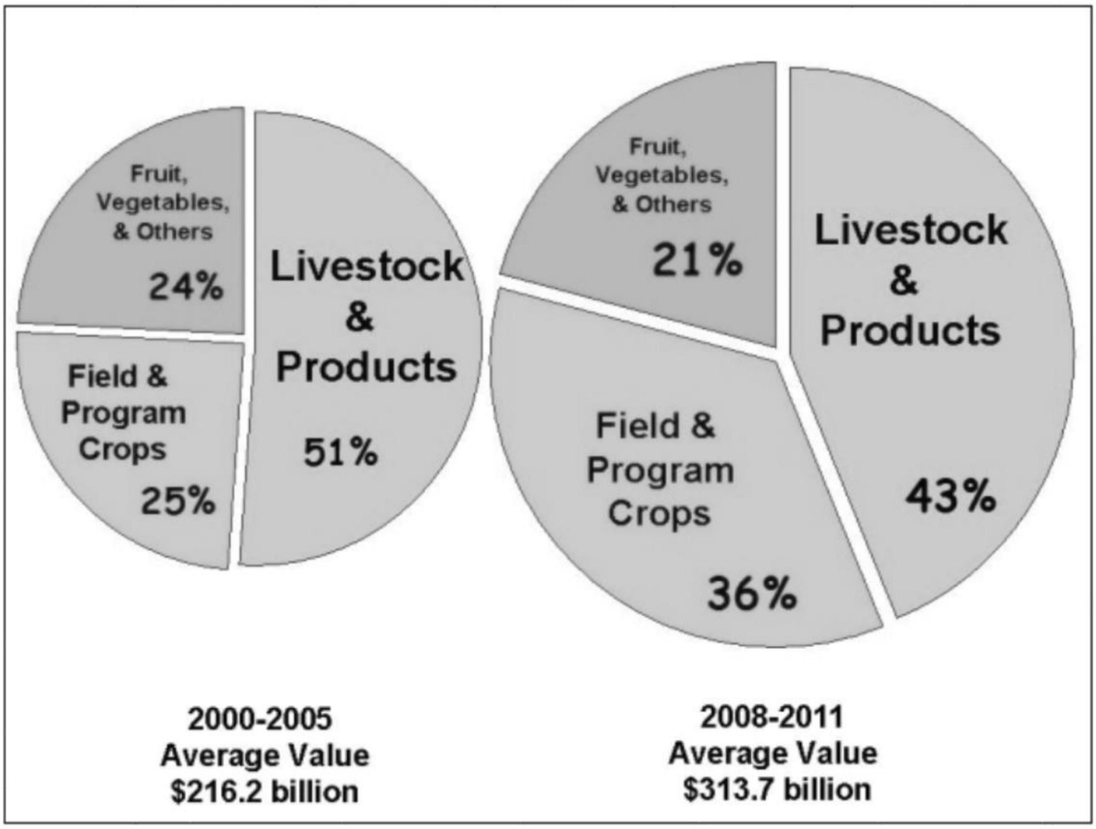


Source: Calculations by CRS using data from NASS, USDA, July 31, 2011.

Objectives

The primary purpose of this paper is to show how U.S poultry supply response to changes in corn prices feed which is reflected by using the quarterly price of corn received by U.S farmers. The main poultry production sectors we will consider are the broiler, turkey, and overall poultry quarterly productions. Using this information a short and long run price elasticity of demand for corn feed and Nerlovian adjustment coefficients for both broiler, turkey, and total poultry production industries. The adjustment factor will show which one of the above poultry production response faster to changes in the price of corn feed. Along with that, there will be a time trend estimate which indicates technological change and resource allocation over time for poultry production in the U.S.

Figure 3. U.S.Agriculture Sector Value Shares



Source: Economic Research Service (ERS), USDA, February 14, 2011.

-In a study on how corn and soybean meal prices fluctuation impacts the demand, and supply of U.S broilers, (Pothidee, Allen, and Hudson 1999) used quarterly data from 1976 to 1996-. One of their findings shows that an increase in corn and soybean meal prices will have an immediate effect on quantities and prices of U.S broilers. As broiler production cycles take about 6-8 weeks, producers adjust their output within three months in response to a change in profit margin caused by high feed prices.

In a study by , (Marsh 2007) to measure the cross-effect between livestock, poultry and corn supply and demand, they found that a shock in livestock and poultry market influence the demand and supply of corn more than shocks from corn market. Mad cow disease (BSE) in the United States and Canada ias an example of shock in livestock which caused a decline in corn revenue in the U.S by 0.62 billion dollars or 5% of 2003 corn revenue.

Methods

-We will use (Nerlove 1979) partial adjustment model, which- assumes that production at a particular time is dependent on the input price in the previous period and quantity of the product made in prior period. Besides that, there are time trend variables which reflect technological changes and resource allocation over time. The dependent variable is poultry desired or planned population at time t denoted as Y_t^* which depends on lagged price of corn P_{t-1}, lagged poultry production Y_{t-1} and error term ε_t,

$$\ln Y_t^* = \beta_0 + \beta_1 \ln P_{t-1} + \beta_2 \ln Y_{t-1} + \varepsilon_t \qquad (1)$$

The poultry production does not change instantly to Y_t^* with a change in feed price from previous period but rather partially adjust and follows equation:

$$\ln Y_t - \ln Y_{t-1} = \theta (\ln Y_t^* - \ln Y_{t-1}) + \varepsilon \qquad (1a)$$

Where ln is the natural logarithm and θ is the Nerlovian coefficient of adjustment which is value is between zero and one, $0 \leq \Theta \leq 1$-.

-After substituting Y_t^* in the above model and including (t) to account for the effect of policy and technological changes, the rearranged equation looks like the following:

$$\ln Y_t = \beta_0 + \beta_1 \ln P_{t-1} + \beta_2 \ln Y_{t-1} + \beta_3 \ln t + \varepsilon_t \qquad (1b)$$

Where, $\beta_0 = \theta a$; $\beta_1 = \theta b$; $\beta_2 = (1 - \theta)$

The θ is the Nerlovian Coefficient of adjustment. It ranges from 0 to 1, and it shows how fast poultry producer adjust their production anticipation when changes in the price of feed happen,s or other factors change. (P_{t-1}) is the lagged price of feed and represent short-run elasticity of demand for corn feed, (Y_{t-1}) is the lagged poultry production and (t) is a typical log of time which show changes in technologies or policies.

Ordinary Least Square can be used to estimate the coefficient of log-log model. In the model, the βs are estimated coefficients and measures of elasticities of Y about X, in which a percentage change in the independent variables X contributes percentage change in Y holding everything constant.

As for the long-run price elasticity of demand can be calculated by the following equation;

$$L/R = \frac{Sr}{1-\beta_2}$$

$\beta_2 = \theta$

$Sr = \beta_1$

$QB_t = f(Pcn_{t-1}, QB_{t-1,,}, T)$

$$\ln Q_t = \beta_0 + \beta_1 \ln Pcn_{t-1} + \beta_2 \ln Q_{t-1} + \beta_3 \log T \quad (1)$$

$$\ln QB_t = \beta_0 + \beta_1 \ln Pcn_{t-1} + \beta_2 \ln QB_{t-1} + \beta_3 \log T \quad (2)$$

B0=θa; B1=θb;; B2=(1-θ)

$QT_t = f(Pcn_{t-1}, QB_{t-1,}, T)$

$$\ln QT_t = \beta_0 + \beta_1 \ln Pcn_{t-1} + \beta_2 \ln QT_{t-1} + \log T \quad (3)$$

$$\ln QP_t = \beta_0 + \beta_1 \ln Pcn_{t-1} + \beta_2 \ln QP_{t-1} + \beta_3 \log T \quad (4)$$

Data Section

Data used in this paper are obtained from ERS Yearbook reports and USDA Feed Grain Database. The study period ranges from 2000 to June 2015. Quarterly production data for broiler production, turkey production, and total poultry production in a -million pound increments is utilized. Data for the quantity of corn feed used (millions of bushels per year) and quarterly corn prices received by farmers in the U.S.

Table 1. Variable Definitions of Broiler and Poultry model

Variable	Definition
QB_t	Quantity of Broiler Produced (Million pounds)
QB_{t-1}	Lagged Quantity of Broiler Produced (Million pounds)
Q_t	Quantity of Turkey Processed, ready to cook weight (Million pounds)
QT_{t-1}	Lagged Quantity of Turkey Processed, ready to cook weight (Million pounds)
Q_P	Quantity of Total Poultry Processed, ready to cook weight (Million pounds)
QP_{t-1}	Lagged Quantity of Total Poultry Processed, ready to cook weight (Million pounds)
Pcn_{t-1}	Lagged Price of Corn (Dollar per bushel)
θ	Nerlovian Coefficient of Adjustment
Log T	Natural log of time

We use adjustment model to estimate Nerlovian Adjustment coefficient θ for broilers and turkey and whole poultry production in the United States and show how their production response to changes in corn feed prices. The θ coefficient value is between 0 and 1. When θ is greater or equal to 0.5, it's considered significant. The adjustment factor is based on Hick's price elasticity of expectation. In the OLS regression for equation (2),(3) and (4), the estimated coefficient had the expected signs and was reasonable. We evaluated the equations in few aspects, as Follows:

Model and Variable Test of Significance

-First checking if the models have explanatory power, for the all three equations, the p-value for the F-test was less than the significance level of 5% and we can reject the null which states that the model does not have explanatory power. Then the individual t-test for the estimated coefficient was significant at the 5% level for most of the independent variables, as shown in below

Table- 2- estimated regression coefficients for Broiler and Turkey and Total Poultry production

	Variables	*Coefficient*	*Standard Error*	*t-statistic*	*P-value*
Broiler Production	Constant	2.203	0.672	4.01	0.002
	Naturel Log of Broiler Production Lagged	0.538	0.110	4.85	0
	Naturel Log of Corn Prices Lagged	- 0.0134	0.0136	-0.99	0.327
	Log Year	0.383	0.100	3.79	0
Turkey Production	Constant	5.764	0.999	5.77	0
	Naturel Log of Turkey Production Lagged	0.251	0.123	2.03	0.047
	Naturel Log of Corn Prices Lagged	0.0568	0.0206	2.76	0.008
	Log Year	- 0.076	0.087	-0.87	0.388
Total poultry	Constant	2.860	0.761	3.76	0
	Naturel Log of Total Poultry Production Lagged	0.498	0.114	4.34	0
	Naturel Log of Corn Prices Lagged	- 0.005	0.013	- 0.45	0.653
	Log Year	0.340	0.091	3.70	0

Multicollinearity Test

Following the overall model and individual coefficients test of significance, we looked if there is any correlation among the variables in each model and check for multicollinearity among the independent variables for each model. In other words, it shows the linear relationship between the independent variables. Any value over 0.8 suggests high collinearity among the two independent variables. The correlation matrix indicates that the coefficient correlations amongst each for each model separately, other as shown in table 3A, 3B and 4.

Table -3A- Correlation Matrix for Broiler production

Variables	*Naturel Log of Broiler Production Lagged*	*Naturel Log of Corn Prices Lagged*	*Log Year*	*Constant*
Naturel Log of Broilers Production Lagged	1			
Naturel Log of Corn Prices Lagged	-0.0417	1		
Log Year	-0.7804	-0.4826	1	
Constant	-0.8809	0.4186	0.3916	1

Table -3B- Correlation Matrix for Turkey production

Variables	*Naturel Log of Turkey Production Lagged*	*Naturel Log of Corn Prices Lagged*	*Log Year*	*Constant*
Naturel Log of Turkey Production Lagged	1.000			
Naturel Log of Corn Prices Lagged	- 0.4033	1.000		
Log Year	0.0244	-0.7641	1.000	
Constant	-0.8978	0.6876	-0.4621	1.000

Table-4- Correlation Matrix for Total Poultry production

Variables	*Naturel Log of Total Poultry Production Lagged*	*Naturel Log of Corn Prices Lagged*	*Log Year*	*Constant*
Naturel Log of Total Poultry Production Lagged	1			
Naturel Log of Corn Prices Lagged	- 0.119	1		
Log Year	- 0.7487	- 0.4532	1	
Constant	- 0.9153	0.4323	0.4184	1

Heteroskedasticity Test

Another test is to check if the variance of the error term are Homoskedastic or have a constant variance. Maintaining this condition will make the OLS regression efficient. We use Breusch-Pagaen test to examine the error terms are constant. The test follows a Chi-Square distribution with the null hypothesis stating that the error term variance are constant. Since the p-value is greater than 5% significance level for both Broiler and Total Poultry production equation, we cannot reject the null, i.e. the error term are Homoscedastic. However, in the case of rejecting the null hypothesis which means we have heteroskedastic errors. We can solve this issue by running a robust regression the equation. Results for Breusch-Pagaen test are shown in table-5- below.

Table-5- Breusch-Pagen test for error term variance

Model	*Chi Square*	*Prob > chi2*
Broiler Production	0.04	0.847
Turkey Production	2.85	0.0916
Total Poultry Production	0.06	0.8035

Autocorrelation Test

However, after running Breusch-Godfrey Test to investigate the independence of the error terms, we found that both equation (2) (3) and (4) do not suffer from Autocorrelation for in their first lag. The Breusch-Godfrey test of autocorrelation is preferred in this situation because we have a lagged dependent variable on the right-hand side of the three equations. The P-values were greater than the significance level of 5%, and we cannot reject the null hypothesis which assumes the presence of no autocorrelation among the error terms. In other words, the error terms for some period are not correlated to the error term of pervious period. Table 6 shows that results for Breusch-Godfrey test as follows:

Table-6- Breusch-Godfrey Test for Autocorrelation

	Lags	*Chi Square*	*Degrees of Freedom*	*Prob > chi2*
Broiler Production	1	2.593	1	0.1073
Turkey Production	1	1.589	1	0.2075
Total Poultry Production	1	1.936	1	0.1641

Poultry Production response to corn price

The variable names are described in table 1. The equation (2), (3) and (4) determines how broiler and turkey and total poultry production adjust to the price of corn feed which constitutes a significant portion of poultry feed diet. The equations are based on Nerlove (Nerlove 1979) which- relies on stock adjustment principle. It suggests that production at a point in time (t) is dependent on the price of feed in last period and the poultry production changes in response to feed prices and quantity of poultry produced in last period. The closer the θ to 1 the faster the production adjustment is to the evolution in price of corn feed prices. On the contrary, values less than 0.5 shows slower change in quantities produced. Table 7 show the adjustment coefficients for broiler and turkey separately and overall poultry production in the U.S.

Regression coefficients Table-7-

Estimates	β_0 Constant	β_1 ln Pcn $_{t-1}$	B2 ln Y_{t-1}	B_3 log T	θ	L/R
Broiler	2.203**	- 0.0134	0.538**	0.383**	0.462	- 0.029
Turkey	5.764**	0.0568	0.251**	- 0.076	0.749	0.075
Poultry	2.860**	- 0.005	0.498**	0.340**	0.502	- 0.009

Note: ** show the significance level at 5%

Change in Feed prices and its impact on poultry production

-The regression coefficients are presented in table 2 for broiler, turkey, and total poultry production. The Overall p-values associated with the F-test for the regressions were significant, as for the individual t-statistic for the estimated coefficient of interest in each equations are not significant. The Estimated coefficients for lagged corn price and lagged poultry production had their expected signs and reasonable. Expect the sign of lagged corn price for turkey which did not have the expected negative sign. The adjustment coefficient θ for broiler and turkey and total poultry were 0.462, 0.749 and 0.502 respectively. Since most of the coefficients are less than 0.5, the change in production is moderate for all except turkey production which was higher. Though the adjustment factor for turkey is higher than of broiler production, this suggests that turkey production will adjust faster in response to changes in the previous price of corn feed.

The short-run price elasticity- of demand for of corn feed for broilers is reflected by coefficient estimate β_1 which was - 0.0134 that shows that an increase in the lagged price of corn will have a small impact on the current broiler production. While the long-run price elasticity of broilers is - 0.029, this shows the increase of corn feed prices has a smaller impact in the long-run on broiler production. This potentially contributes less to a reduction in the quantity of broiler produced and might cause higher prices at the retail level. As for total poultry production, the short-run price elasticity of demand for corn feed is - 0.005, put another way, this can be interpreted as partial elasticity in which one percentage increase in the price of corn feed in previous period would decrease current total poultry production by - 0.005 percent in the short-run holding everything constant. The total poultry production seems slightly more impacted by variations in corn feed prices in the long-run L/R with the long-run elasticity of - 0.009. On the other hand, turkey production did not seem affected much by in either short-run or long-run price, and the results were inconsistent for turkey production. Results are shown in table 7 above.

Time Trend Variable

The coefficient of time trend represent technological changes and assumes that the supply curve has changed outward. The time trend is statistically significant at 5% significance level for all of the broiler and total poultry production and has the expected positive signs. The positive time trend estimate in the regression reflect the increase in resources allocation for poultry production in the U.S over time.

Lagged Poultry Production

The previous poultry production estimate in the regression have the expected signs and makes sense. Since US is one of the major poultry producers in the world and second largest poultry meat producer in the world according to USDA. And the domestic poultry consumption has increased for the local consumer who is measured in per capita consumption of poultry in pounds. According to statistics from the National Chicken Council, per capita consumption of poultry meat increased from 34 pounds to over 100 pounds in the US from the year 1960 to 2015. Also, the quantity of broiler export from the U.S and its share of total broiler production has increased over the years. In 1960 the total broiler export in the U.S was 93,000 pounds and made 2.1% of broiler production that year. In 2014 the total broiler exported was 7,301,000 pounds and formed 19 % of total broiler production that year.(National Chicken Council).

Conclusion

This paper seeks to estimate US aggregate poultry supply responses to corn feed price changes through Nerlovian adjustment model. It uses quarterly data from corn feed consumed, quarterly corn prices in the US from year 0f 2000 to 2015 and quarterly broiler, turkey and total poultry production in the form of net ready to cook poultry meat. Since corn constitutes a significant portion of poultry diet and cost expenses. Also, corn has been used dominantly in the U.S in ethanol production which caused fluctuation in its price over the years. The main finding in this paper was that previous- corn feed prices negatively affect U.S poultry production and have a negative impact on the different sectors of the poultry industry and the long-run effect of corn price were greater than short-run-.

Our result shows that lagged corn feed prices negatively contribute to both U.S broiler and total poultry production. Both estimates for lagged corn prices had the expected negative signs. The estimated also reflect short-run price elasticity of demand for corn feed that was --0.0134 and - 0.005 for broiler and total poultry respectively. The broiler production seems slightly more negatively affected by the lagged price of corn feed than total poultry production.

The Nerlovian adjustment coefficient θ shows how fast the production of broiler and total poultry adjust to changes in lagged price of corn feed. The adjustment factors for broiler and total poultry production were 0.462 and 0.502 respectively. This means that overall poultry production response more a bit faster to fluctuations in lagged corn prices. In other words, current poultry production is inversely correlated with the previous price of corn feed. As for the long-run price elasticity of demand for corn feed were - 0.029and - 0.009 for broiler and total poultry respectively. This indicates that broiler production is more responsive to corn price fluctuation in the long-run- and more likely to cause a reduction in the quantity of broilers- raised at the farm level when corn prices are high, since the biggest share of operation cost in poultry production goes to feed which is about 60% to 70%. In this situation, this can hurt both chicken growers at one end because they are left with less profit due to high feed cost and customers of the other end which can face a higher poultry meat prices at the retail level because there is fewer meat available.

Sometimes new policies regarding export quota to corn and poultry meat could provide some price stability for corn feed which allows the poultry growers to bear less cost while raising more broilers to be processed and go to the market. At the same time, restricting poultry meat export could prevent poultry prices from surging and protecting local customers. These results could be used in the future to guide policy makers the ramification needed to the Renewable Fuel Standard (RFS) and possibly reduce the RFS mandate to an extent that prevent surge in corn price and damaging other sectors of the food industry. Or initiate government subsidy programs that compensate the poultry grower for high feed costs.

There are more venues that need to be explored regarding poultry production, such as improving new diet that allows faster grow and less feed quantity to produce poultry meat which in turn may save some cost on feed when there is more efficient feed available. Or keeping high corn stock for feeding purpose and in the case of any unexpected corn price surges in the future.

References

Donohue, M, and DL Cunningham. 2009. "Effects of grain and oilseed prices on the costs of US poultry production." *The Journal of Applied Poultry Research* 18 (2):325-337.

Leeson, S, and JD Summers. 2005. "Ingredient evaluation and diet formulation: Flaxseed." *Commercial Poultry Nutrition. 3rd ed. University Books, Guelph, Ontario, Canada*:44-46.

Marsh, John M. 2007. "Cross-sector relationships between the corn feed grains and livestock and poultry economies." *Journal of Agricultural and Resource Economics*:93-114.

Nerlove, Marc. 1979. "The dynamics of supply: retrospect and prospect." *American journal of agricultural economics* 61 (5):874-888.

Pothidee, Ajchara, A Allen, and Darren Hudson. 1999. "Impacts of Corn and Soybean Meal Price Changes on the Demand and Supply of US Broilers." *Mississippi State University*.

Schnepf, Randy. 2011. "US Livestock and poultry feed use and availability: Background and emerging issues." *Congressional Research Service. http://www. nationalaglawcenter. org/assets/crs* 41956.

Stillman, Richard, Mildred Haley, and Ken Mathews. 2009. "Grain prices impact entire livestock production cycle." *Amber Waves* 7 (1):24.