Impacts of Corn and Soybean Meal Price Changes on the Demand and Supply of U.S. Broilers[1]

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Extended Abstract:

This study examined factors that affected the prices of corn and soybean meal and the impact of these prices on market demand and supply for U.S. broilers. An econometric model consisting of four structural equations and one identity was formulated and estimated using quarterly data from 1976 to 1996. One of the results reveal that soybean meal price flexibilities with respect to soybean price were highly elastic in both the short and long run. This means that changes in soybean prices have a relatively large effect on meal price. In contrast, meal price and oil price moved in opposite directions. An increase in oil price encourages an increase in crushing oilseeds, resulting in an increase in both oil and meal supply. In addition, results indicated that a sustained increase in corn and soybean meal prices will have an immediate impact on broiler quantities and prices.

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Introduction

The importance of the broiler industry in U.S. agriculture has been recognized for several decades. The growth of this industry is a great success story. The broiler industry has significant relationships with other related industries, especially the feed industry.

There are no government programs designed to specifically influence broiler production and marketing. Generally, the poultry industry benefits indirectly through farm loan programs administered by USDA's Farm Service Agency and previously by the Farmers Home Administration- FmHA (ERS, USDA 1996), Federal and State inspection, research services, and special tax provisions (U.S. International Trade Commission). Farm programs that affect feed grains and oilseeds directly affect feed prices, and therefore broiler production costs.

As livestock production operations have become larger and more specialized, leading to fewer mixed enterprises, the interdependencies between feed and livestock have become more significant (Westcott, Stillman, and Collins). Livestock producers, therefore, are now more sensitive to the variation in feed prices. Even small policy changes for feed can have large effects on the livestock and the broiler industries because of the importance of feed costs in the production process. Consequently, the effects of corn and soybean meal prices, the major ingredients in broiler ration, on the U.S. broiler industry could be quite profound. The various factors affecting prices of corn and soybean meal, and consequently the potential impact of those corn and soybean meal prices on market demand and supply for the U.S. broilers were examined in this study.

Data Sources and Methods

Data on corn prices, stocks, total disappearance, soybeans, soybean meal, and soybean oil, meat prices and quantities were obtained from various issues of USDA, ERS Situation and Outlook Reports and CRB Commodity Yearbooks. The Survey of Current Business provided the data on disposable personal income and population. The CPI Detailed Report provided the data on consumer price index (CPI).

To accomplish the objective of this study, an econometric model consisting of four structural equations and one identity was formulated and estimated using quarterly time series data from 1976 to 1996. The equations were the price relationships of corn, soybean meal, a broiler price dependent demand equation, and broiler production.

The equations for prices of corn and boilers were estimated using the Cochrane-Orcutt interactive maximum likelihood method. The equations for the price of soybean meal and the broiler production equations were estimated using two stage least squares. The price functions of corn and soybean meal, the demand and supply functions for broilers, and one identity are shown below. The variables are defined in Table 1.

Corn price function:

$$(1) \qquad P_c = f(P_{c(t-1)}, (S_c/U_c)_{(t-1)}, EX_{c(t-1)})$$

Soybean meal price function:

$$(2) \qquad P_{sm} = f(P_{sm(t-1)}, P_{sb(t-1)}, P_{so(t-1)}, (S_{sm}/U_{sm})_{(t-1)}, D_2, D_3, D_4)$$

Broiler demand function:

$$(3) \qquad P_b = F\left(\frac{Q_{bd(t-1)}}{P_{us.}}, \frac{Q_{bf(t-1),}}{P_{us.}} \frac{Q_{ty(t-1)}}{P_{us.}}, \frac{Y_{(t-1)}}{}, EX_{b(t-1)}, D_2, D_3, D_4\right)$$

Broiler supply function:

$$(4) \quad Q_{bs} = (P_{b(t-1)}, P_{c(t-1)}, P_{sm(t-1)}, HATCH_{(t-1)}, Q_{bs(t-1)}, D_2, D_3, D_4)$$

Identity:

$$(5) \quad Q_{bs} = Q_{bd}+EX_b+I_b$$

To investigate the impact of changes in corn and soybean meal prices on broiler production and price, dynamic multipliers were derived from reduced-form equations. These multipliers were estimated as impact, interim and total effects. Dynamic multipliers indicate how endogenous variables in a model respond to changes in exogenous variables.

Results and Discussion

This section of the paper is divided into three subsections. The first and second subsection deal with price flexibilities and elasticities of supply, respectively. The third subjection deals with multipliers.

Price Flexibilities

The price flexibilities of corn, soybean meal, and broilers with respect to various exogenous variables are presented in Table 2. The effect of the stocks-to-use ratio on corn prices is inelastic and negative in the short run but inelastic and positive in the long run. These results reveal that, in the short run, an increase in the stocks-to-use ratio by one percent would reduce corn prices by 0.03 percent. In the long run, an increase in the stocks-to-use by one percent would increase the corn price by 0.58 percent. Generally, the stocks of corn are largest

during the harvest period in the first quarter of the crop year (September-August), resulting in low corn prices in that time period. After the harvesting period, corn prices tend to increase to reflect the costs of carrying the crop in storage.

Effect of corn exports on corn prices was highly inelastic in the short run but highly elastic in the long run. This result indicates that an increase in corn exports of one percent would cause an increase in corn prices of 0.08 percent in the short run, but would cause an increase in corn prices of 2.13 percent in the long run.

The impact of soybean prices on soybean meal prices was elastic in the short and the long run. An increase in bean prices by one percent resulted in an increase in meal prices by 1.24 and 1.52 percent in the short run and long run, respectively.

Prices of soybean meal and soybean oil move in the opposite directions. High oil price encourages an increase in crushing oilseeds which subsequently increases the supply of both oil and meal. As a result, a meal surplus tends to decrease meal price. Alternatively, if the meal market is strong relative to the oil market, an increase in crushing oilseeds would result in decreasing the oil price. The effect of soybean oil prices on soybean meal prices was inelastic. This result reveals that an increase in oil prices by one percent would result in a reduction of meal prices by 0.42 and 0.60 percent in the short run and long run respectively.

The own-price flexibilities for broilers were negative by -1.53 and -2.03 percent in the short run and long run, respectively, or own-price elasticity of demand was inelastic. This result is consistent with previous studies in that price elasticity of demand has become more inelastic, or consumers are less responsive to price changes than in the past.

The cross-price flexibility with respect to a change in per capita consumption of beef and turkey had negative signs meaning that beef and turkey meat were substitutes for broiler meat. The cross-price flexibilities of broilers with respect to changes in beef quantity were -0.42, and -0.56 in the short run and long run, respectively. In addition, the cross price flexibilities of broilers with respect to changes in turkey quantity were -0.17 and -0.23 in the short run and long run, respectively. While beef and turkey meat were substitutes for broiler meat, pork was not. This result confirms findings from several previous studies that poultry consumption was increasingly less affected by the pork market (Chavas; Rosichon; Thurman).

Elasticities of Supply

The elasticities of supply are presented in Table 3. All elasticities of supply with respect to output and input price changes were inelastic in the short and long run. The inelastic price elasticity of supply suggest that producers have become less responsive to price changes. In contrast, broiler supply response to the previous quarter of chicks hatched was elastic (1.28).

Broiler production in any time period varies due to seasonal effects. The weather-related stress can affect the efficiency of the laying flock at different times in the year, which then affects production three months later (Baker and Westcott). For example, for a given size laying flock, summer stressful periods may reduce broiler production in the fall. The less stressful spring period results in a larger supply of hatching eggs for summer period production of broilers (Baker and Westcott). Seasonal dummy estimates indicated that broiler production was highest in the first quarter, January through March.

Multipliers of Corn and Soybean Meal Prices

The results dynamic multipliers of corn and soybean meal prices are presented in Table 4. For the multipliers of corn price, a sustained increase in the price of corn by one percent would cause an immediate reduction in broiler production by 0.021 percent. The interim multipliers showed little impact on broiler production and approached zero. The total effect resulted in a reduction of broiler production by 0.028 percent in the long run. The multiplier effects of corn prices on broiler prices were compared to the production effects. The impact multiplier was 0.070 percent. The interim multipliers were considerably dampened after two periods. The total effect was an increase in broiler prices by 0.090 percent in the long run.

The multiplier effects of soybean meal prices showed that a sustained one percent increase in soybean meal prices would reduce broiler production by 0.025 percent and increase broiler prices by 0.089 percent in that given quarter. Most of the impact was completed by the end of the second period. In the long run, the total effect of an increase in soybean meal prices by one percent reduced broiler production and increased broiler prices by 0.032 and 0.118 percent, respectively.

The multiplier effect suggests that there is an immediate, but relatively small adjustment to a soybean meal price change. Further, this immediate adjustment was the largest portion of the total adjustment. Rigidities in the system from growers to processing plants (e.g. fixed contract periods and capacity constraints) may limit adjustment.

Summary and Conclusions

Results indicated that a sustained increase in corn and soybean meal prices had an immediate impact on broiler quantities and price. Since broilers have a production cycle of 6-8

weeks, producers can adjust their production in response to changing profit conditions within a three month period. Interim multipliers were considerably dampened after two periods. The total effect of a percentage increase in corn price was a reduction in broiler production and an increase in broiler prices by 0.028 and 0.090 percent, respectively. In addition, the total effect of a percentage increase in soybean meal price was a reduction in broiler production and an increase in broiler prices by 0.032, and 0.118 percent, respectively. The magnitude of this impact was not large due to the limitations of adjustments in the production process.

Broiler price was found to be more responsive to input price changes than on the magnitude of broiler production. This was due to the high own-price flexibility of demand (-1.53 and -2.03 in the short and long run) which implied the inelastic demand for broiler meat. Consequently, an upward shift in the supply curve was mostly passed on to the consumers in the form of higher prices.

A major impact on corn price was corn export volume. Additionally, soybean meal price was greatly affected by changes in soybean prices. Consequently, changes in the volume of corn exports and in soybean price indirectly affected broiler production and price. In sum, these findings implied that policies that affected corn and soybean meal prices would have almost an immediate impact on the broiler industry.

Table 1. Description of variables used in the study

Variables	Description	Unit
Price of corn (P_c)	No. 2 yellow, Chicago	Dollars/bushel
Price of soybean (P_{sb})	No. 1 yellow at Illinois processors	Dollars/bushel
Price of soybean meal (P_{sm})	48% protein, Decatur	Dollars/ton
Price of soybean oil (P_{so})	Crude, Decatur	Cents/pound
Price of broilers ($P_{b)}$	12-city composite wholesale price, ready-to-cook	Cents/pound
Stocks of corn (S_c)	Stocks at the end of quarter	Million bushels
Total use of corn (U_c)	Domestic use and exports	Million bushels
Stocks of soybean (S_{sb})	Stocks at the end of quarter	Million bushels
Stocks of soybean meal (S_{sm})	Stocks at the end of quarter	Thousand short tons
Stocks of soybean oil (S_{so})	Stocks at the end of quarter	Million pounds
Total use of soybean (U_{sb})	Crush and exports	Million bushels
Total use of soybean meal (U_{sm})	Domestic use and exports	Thousand short tons
Total use of soybean oil (U_{so})	Domestic use and exports	Million pounds
Quantity of broiler production (Q_{bs})	Ready-to-cook	Million pounds
Quantity of broiler consumption (Q_{bd})	Ready-to-cook	Million pounds
Quantity of beef consumption (Q_{bf})	-	Million pounds
Quantity of turkey consumption (Q_{ty})	-	Million pounds
Chicks hatched (HATCH)	Broiler chicks hatched in commercial hatcheries	Million heads
Quantity of corn exports (EX_c)	-	Million bushels
Quantity of soybean exports (EX_{sb})	-	Million bushels

Table 1. Description of variables used in the study (continued)		
Quantity of soybean meal exports (EX_{sm})	-	Thousand short tons
Quantity of soybean oil exports (EX_{so})	-	Million pounds
Quantity of broiler exports (EX_b)	All forms	Million pounds
Disposable personal income (Y)	-	Billion dollars
Population (P_{us})	U.S. resident population plus armed forces overseas	
CPI	Consumer price index for all urban consumers, all items, 1982-84 = 100	
t-1	lagged variable from previous t^{th} quarter	-
D_2	Dummy variable for quarter 2, D_2 = 1 for quarter 2, otherwise = 0	-
D_3	Dummy variable for quarter 3, D_3 = 1 for quarter 3, otherwise = 0	-
D_4	Dummy variable for quarter 4, D_4 = 1 for quarter 4, otherwise = 0	-
I_b	Net stocks of broilers	Million pounds

Table 2. Estimated short-and long-run price flexibilities for corn, soybean meal, and broilers.

Price Flexibilities with Respect to:	Short Run	Long Run
Corn price		
Stocks-to-use-ratio	-0.03	0.58
Exports	0.08	2.13
Soybean meal price		
Soybean price	1.24	1.52
Soybean oil price	-0.42	-0.60
Stocks-to-use ratio	-0.05	-0.07
Broiler price		
Broiler quantity	-1.53	-2.03
Beef quantity	-0.42	-0.56
Turkey quantity	-0.17	-0.23
Income	1.95	2.60
Exports	-	0.05

Table 3. Estimated short- and long-run elasticities of supply of broilers

Supply Elasticities with Respect to:	Short Run	Long Run
Own price	0.09	0.14
Corn price	-0.02	-0.04
Soybean meal price	-0.04	-0.06
Chicks hatched	-	1.28

Table 4. Multipliers of prices of corn and soybean meal

Endogenous Variables	Impact Multipliers	Interim Multipliers 1	2	3	4	5	6	7	8	9	10	11	12	Total Multipliers
		Percentage change												
Multipliers of price of corn														
Q_{bs}	-.0211	.0028	.0011	.0004	-.0077	.0007	.0003	.0001	-.0029	.0001	.0001	.0000	.0000	-.0279
P_b	.0703	.0268	.0102	.0039	-.0094	-.0021	-.0003	.0001	-.0033	-.0011	.0003	.0000	.0000	.0904
Multipliers of price of soybean meal														
Q_{bs}	-.0246	.0036	.0014	.0005	-.0090	.0009	.0004	.0001	-.0039	.0002	.0001	.0000	.0000	-.0317
P_b	.0893	.0340	.0129	.0049	-.0107	-.0022	-.0002	.0002	-.0045	-.0013	-.0003	.0000	.0000	.1180

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