Journal of Agricultural and Applied Economics, 28,2(December 1996):279–289

Asymmetric Price Relationships in the U.S. Broiler Industry

John C. Bernard and Lois Schertz Willett

ABSTRACT

This study presents a testing methodology to analyze potential price asymmetries among the farm, wholesale, and retail levels of the U.S. broiler industry. Lag length, direction of causality, and asymmetric relationships are empirically determined. Results suggest that concentration and power of the integrators in the industry have allowed the wholesale price to become the center, causal price in the market. Asymmetric price transmissions, however, are limited. While downward movements in the wholesale price are passed on more fully to growers than increases in the wholesale price, only consumers in the North Central region of the U.S. share a larger portion of wholesalers' price increases than price decreases.

Key Words: asymmetry, broilers, concentration, Granger causality, price transmission.

Price changes between market levels and among spatially separated markets should be symmetric. Considerable attention, however, has been devoted to determining if price transmissions act differently dependent on the direction of the initiating price change. Of paramount concern has been whether or not wholesalers of some agricultural commodities have the power to asymmetrically influence the prices on the farm and retail levels. Past studies addressing this question have focused on commodities such as fresh vegetables (Ward), dairy products (Kinnucan and Forker), citrus (Pick, Karrenbrock, and Carman), cattle (Bailey and Brorsen), and pork (Boyd and Brorsen; Punyawadee, Boyd, and Faminow), and have reached varying conclusions. Our study examined price relationships in the U.S. broiler industry using a complete, refined testing methodology built on the efforts noted above.

The methodology is complete in that empirical tests are used at every stage of the analysis. The four-step procedure begins with unit root testing to determine the correct form for the data, continues with lag length determination and causality tests for flow durations and direction, and concludes with asymmetry tests. The methodology is refined in its use of multiple criteria and testing strategies where questions have arisen concerning their appropriateness in varying situations.

The broiler industry has not been investigated previously for asymmetry, despite structural reasons for concern. Especially apparent is the increased wholesale concentration in the industry. Further, the broiler industry is highly vertically integrated, giving the wholesale level strong influence throughout the market. Additionally, the spatial aspect of broiler produc-

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The authors would like to thank Robert Kalter and two anonymous journal reviewers for their helpful suggestions. This research was supported in part by Hatch Contract NYC-121407.

tion means regional variations in price transmissions may exist.

The three specific objectives of this research were to determine if: (*a*) decreases in the wholesale price of U.S. broilers are passed on to growers more than increases, (*b*) consumer prices respond more to increases in the broiler wholesale price than to decreases, and (*c*) these price transmission processes vary by region at the retail level.

Broiler Industry Structure

The modern broiler industry is marked by many structural elements of imperfect competition: high concentration, vertical integration, advertising, and product differentiation. While vertical integration has long existed, these other conditions have come into prominence during the recent past. In particular, through expansions and buyouts over the decade examined in our study (1983 through 1992), the industry's four-firm concentration ratio rose from 32.8 to 40.4 (*Broiler Industry*). This concentrated wholesale level consists of large, vertically integrated firms called integrators. Integrators own hatcheries, feed mills, and processing plants. They typically purchase eggs from breeders while hatched chicks are sent out to growers under contract.

Approximately 90% of all broilers are grown under contract. The contractual arrangement between grower and integrator makes a grower's proximity to integrators especially important. One obvious risk to a grower is the possibility of the local integrator closing down or relocating. The risk from the point of view of this study, however, is that the integrator will take advantage of growers, offering them prices below competitive levels.

Provision of inputs is split between grower and integrator. The grower provides housing and labor, and pays for water, fuel, and electricity. In addition to the broiler chicks, the integrators supply the feed, vaccines, and any necessary medications. When the broilers have matured enough for market, they are returned to the integrator where they are processed and shipped, primarily to retail outlets.

The U.S. broiler industry is geographically concentrated into four regions: South, Northeast, West, and North Central. It is the southern states, particularly Arkansas and Georgia, which dominate the nation in broiler production. This geographic concentration suggests the potential for price transmissions to vary spatially.

Another key development in the broiler industry has been the changing nature of the end product. Percentage of sales represented by the traditional whole, fresh broiler examined here declined throughout the sample period. The bulk of the market now consists of further processed products, fast food nuggets, and other, harder to quantify forms. Despite this trend, whole broilers still represent a sufficiently significant portion of the market for examining the competitiveness of price transmissions while avoiding the complications of calculating margins for extensively processed products.

Theoretical Considerations of Price Transmissions

Early research in perfectly competitive price transmission processes suggested that consumer demand determined retail price, with lower market-level prices being determined by subtraction of processing, transportation, and other costs (Thompson and Lyon). Models based on this theory considered price spreads to be derived through percentage or absolute price markups, or a combination of the two.

Gardner later constructed a model to incorporate the concept that supply and marketing services, as well as demand, were relevant to price spreads. In this framework, markups change in different ways depending on whether the price change began on the farm supply or retail demand side of the industry. The substantial demand increases experienced by the broiler industry during the sample period could thus be used in this model to explain any evidence of asymmetry. As Kinnucan and Forker suggest, however, growing stocks should insulate prices from the effects of demand shocks—and growing stocks were evident in the broiler industry over the sample period.

Heien's margin work was important in analyzing the direction of price transmissions in competitive markets. He developed a dynamic markup model where, at each successive market level from farm to wholesale to retail, the price was based on the preceding level's price plus some markup. Thus, price changes flowed from farm to wholesale to retail. Heien's model depends on the assumptions of constant returns to scale and fixed proportions, conditions which Wohlgenant's work has suggested exist in the U.S. broiler industry.

Wohlgenant's sample period, however, predates that of this study and the industry's increased concentration.[1] Ward reported that such concentration may yield informational advantages that could lead prices to emanate outward from the wholesale market level to farm and retail levels. For instance, a concentrated wholesale level, as in the broiler industry, may be the center of price formation in the market. Supply and demand factors in such a model have less effect on margins and flows than in the competitive models.

In connecting theory and empiricism, this research on the broiler industry empirically examines price transmissions in a manner theoretically consistent with Ward. Characteristics of industry structure were considered more important than supply and demand concerns. Direction of price flows was tested, rather than assumed on the basis of any of the discussed models.

Methodology

Most asymmetry studies stem from Wolfram's method for splitting irreversible variables for regression modeling. While Wolfram's method, and Houck's subsequent refinements, were useful, they were appropriate only within a static framework. Ward captured the dynamics of price transmissions by adding the influences of past prices, while Boyd and Brorsen expanded asymmetry testing to include testing speed of price adjustments alongside overall effects. The four-step procedure utilized here closely matches the further improvements of Bailey and Brorsen.

Since autocorrelation has been a common problem in asymmetry studies (Kinnucan and Forker; Pick, Karrenbrock, and Carman; Boyd and Brorsen), the initial step was to determine the correct form for the data by conducting unit root tests. Many economic time series are nonstationary, typically exhibiting a trend away from an initial value. To remove trend, it must first be determined whether a model is a trend stationary process (TSP) or a difference stationary process (DSP). A TSP model should be detrended with the inclusion of a trend variable, while a DSP should be detrended by using first differences (Nelson and Kang). A model is identified as a DSP if it has a unit root.

Unit root testing for the price variables in the data set was performed using the augmented Dickey-Fuller test on a one-period autoregressive model of the form:

$$\Delta u_t = \beta_0 + \beta_1 u_{t-1} + \beta_2 \Delta u_{t-1} + \beta_3 TREND + g_t,$$

where Δu_t is the first difference of the price series at a time i, and a trend and constant term have been included. MacKinnon critical t-values were used to test the coefficient on u_{t-1}, with the null hypothesis of a unit root rejected if the coefficient was determined to be significantly different from zero. From our review of previous studies, only Bailey and Brorsen have tested for unit roots.

The second step was to determine the lengths of time between influences and adjustments among the prices. As bias from an incorrect model will cause parameters to vary from their true values, accuracy in lag length is crucial for both causality and asymmetry testing. Some studies (Boyd and Brorsen; Punyawadee, Boyd, and Faminow) used past studies for lag determination, while Kinnucan and Forker, and Pick, Karrenbrock, and Carman added/subtracted lags until significance

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[1] Wohlgenant's sample period encompassed 1955 through 1983. For the majority of this time frame, it is likely the broiler industry would be analyzed best with a competitive model. The rationale behind the present study is that important structural changes have occurred since the early 1980s.

changed. The present study, like that of Bailey and Brorsen, used selection criteria.

Testing of lag lengths was performed in two stages, following Hsiao's testing methodology for a bivariate autoregressive model. While Hsiao used only Akaike's final prediction error (FPE) criterion, citing its ability to balance the risk of under- or overestimating the correct lag, recent research has used multiple criteria. Since the FPE, as noted by Holmes and Hutton, has a tendency to overfit lags, Schwarz' Bayesian information criterion (BIC) was also used in testing. BIC offers the benefit of asymptotically eliminating the possibility of overestimation, although with an increased chance of underestimation. In contrast, Bailey and Brorsen used only Akaike's information criterion.[2]

The first stage of Hsiao's procedure involves discovery of the lag length of a univariate function, while the second stage considers the bivariate case. For a variable, *Y*, thought to be explainable by itself, and another variable, *X*, the bivariate autoregressive model can be expressed as follows:

$$Y_t = \sum_{i=1}^{m} \beta_i Y_{t-i} + \sum_{j=0}^{n} \beta_{j+m+1} X_{t-j} + e_t,$$

where *m* and *n* are to be estimated.

In both stages, lags were added sequentially. No lag lengths were bypassed or tested for removal once the lag length increased. The first stage of the analysis consisted of univariate testing of each *Y* to determine the order of each of the variables lagged on itself. In the second stage, each of the variables was in turn lagged on all other variables with which it had a theoretical relationship. The dependent variable in each case was itself lagged to the extent discovered in stage one in each regression.

Discovered lag lengths were then used in the equations for causality testing. To determine causality, a test proposed by Geweke, Meese, and Dent, based on Sims' test, was used.[3] To determine if an affected factor (AF) has been acted upon by a causal factor (CF), past values of the causal factor and past, present, and future values of the affected factor were used to explain the present value of the causal factor. This specification was tested against the same specification with the exception of the future values of the affected factor. The unrestricted (1) and the restricted (2) equations were:

$$(1) \quad CF_t = \beta_0 + \sum_{n=1}^{LCF} \beta_n CF_{t-n} + \sum_{m=-LAF}^{LAF} \beta_{LCF+LAF+m+1} AF_{t-m} + \beta_{LCF+2\times LAF+2} TREND_t + u_t$$

and

$$(2) \quad CF_t = \beta_0 + \sum_{n=1}^{LCF} \beta_n CF_{t-n} + \sum_{m=0}^{LAF} \beta_{LCF+m+1} AF_{t-m} + \beta_{LCF+LAF+2} TREND_t + v_t,$$

where, in (1), the lead effect is represented by $m = -LAF$ through -1 on the summation of the affected factor. The lag length and lead length on the affected factor were assumed to be the same (*LAF*).

Results of causality and lag length tests were used to assess the symmetry of price relationships across market levels. The first step in this process was to transform the variables into differences from their initial value. This was done because the hypothesis of reversibility depends on the change in the value, not its level. Independent price variables to be tested for nonreversibility required further transformation. These were segmented by dividing them into their upward and downward movements, such that the new variables were the cumulative sums over time of the increases and decreases, respectively.

[2] We also used this criterion, but the results were identical to Akaike's FPE, and so were not included separately.

[3] Causality testing was also conducted using Granger's original method. However, these results were identical, and so were not included.

Nonsegmented gas prices were then included to represent transportation costs to the different regions. Using $UPCF^*$ and $DWCF^*$ to represent the upward and downward movements of the transformed causal price, AF^* to represent the transformed affected price, and GAS^* for the transformed gasoline price, the unrestricted equation for testing for asymmetric price transmissions can be written:

$$(3) \quad AF_t^* = \beta_0 TREND_t + \sum_{n=0}^{LCF} \beta_{1,n} UPCF_{t-n}^* + \sum_{n=0}^{LCF} \beta_{2,n} DWCF_{t-n}^* + \beta_3 GAS_t^* + w_t.$$

No constant term is included since it cancels out when transformed into its difference from its first value. Lag lengths, LCF, were again as calculated in the lag length determination tests. Additionally, in testing price links involving the farm price, the transformed costs of the two primary inputs were added to the above equation.

Next, a series of restricted equations was estimated. The first restricted equation tested the cumulative effects over all lags, with all up and down variables replaced by the corresponding cumulative sums of the two. Using $FULLCF^*$ to represent a combined price change, and assuming other appropriate independent variables, the form of this equation can be written:

$$AF_t^* = \beta_0 TREND + \sum_{n=0}^{LCF} \beta_{1,n} FULLCF_{t-n}^* + k_t.$$

The restricted and unrestricted equations were compared statistically to determine if increases in the causal price had a different influence than decreases. Tests of significance were performed using the F-statistic. The null hypothesis was that the coefficients on the upward and downward price movements were equal, or:

$$\sum_{n=0}^{LCF} \beta_{1,n} = \sum_{n=0}^{LCF} \beta_{2,n}.$$

Asymmetry was also investigated on a period-by-period basis. For each period, another restricted equation regression was performed, with the upward and downward price movements for that lag period replaced by the combined price change and the other periods left segmented. Using the same notation as in (3), the restricted equations for individual periods followed the form:

$$AF_t^* = \beta_0 TREND + \beta_1 FULLCF_{t-i}^* + \sum_{j=0, j\neq i}^{LCF} \beta_{2,j} UPCF_{t-j}^* + \sum_{j=0, j\neq i}^{LCF} \beta_{3,j} DWCF_{t-j}^* + \epsilon_t,$$

where i was the period being tested, and with any other appropriate nonsegmented independent variables included.

Each period's restricted equation was compared statistically with the unrestricted equation to determine if price transmissions were symmetric in that period. This allowed investigation of the speed of adjustment, similar to the analysis of Bailey and Brorsen and others. The importance of this procedure was to be able to determine if brief asymmetries exist but, as proposed by Pick, Karrenbrock, and Carman, are quickly corrected. The test method was the same as for the cumulative effect comparison.

Data

Monthly data used cover the period January 1983 through December 1992. As the U.S. Department of Agriculture (USDA) changed its reporting methods for the broiler industry in 1983, this was an appropriate starting point. By 1992, the industry's concentration ratio seemed to have stabilized, marking an appropriate endpoint for our study.

National wholesale and farm broiler prices, as well as the costs of the two primary feed ingredients, the Central Illinois price of No. 2 yellow corn and the Decatur price of soybean meal (44% solvent), were taken from selected issues of three USDA publications: *Poultry Market Statistics, Livestock and Poultry: Sit-*

uation and Outlook Report, and *Livestock and Poultry Update.* The wholesale price was a 12-city weighted average series calculated by dividing the country into three marketing regions, and then weighing prices in each region by their population.[4] The composite weighted prices consisted of U.S. Grade A and Plant Grade branded and unbranded whole-carcass products and whole birds without giblets.

The farm price was calculated as the equivalent live weight return to producers. The formula is based on the ready-to-cook price with a combination of processing costs and dressing percentage subtracted. While such a derivation portends possible difficulties with empirical analysis, the series closely mirrored a weekly Arkansas farm price collected from a survey of integrators.

Retail prices for whole, fresh chickens were collected by the U.S. Bureau of Labor Statistics using four U.S. sampling regions: West, South, North Central, and Northeast.[5] Additionally, a national price was calculated as a population weighted average of the regional prices.

For transportation costs, a national retail price of gasoline was collected from *National Petroleum News: Factbook Issue.* This price was an average of all types of gasoline available and includes taxes and variations due to types of service.[6] We believe this series captures any price relationship differences due to the varying distances between concentrated broiler production areas and the spatially distinct retail regions.

Other data variables were investigated, but were not found to be statistically usable.[7] Labor costs specific enough to represent actual costs incurred at the various market levels in the broiler industry, as well as desired marketing costs (especially advertising), were not available. Data problems thus limited the extent to which potential model components could be included. As Ward noted, however, an understanding of pricing relationships can be determined without complete elaboration of the market, and it was believed empirical analysis would not be affected significantly.

Empirical Results

Unit root tests on the data series were evaluated first. The retail price in the South rejected a unit root at the 5% level, while all other broiler price variables, except the Northeast retail price, rejected the null hypothesis of a unit root at the 10% level. The price variables for corn, soy, and gasoline, however, failed to reject the unit root hypothesis. Based on these results and a desire for consistency, equations were constructed as TSP, using levels and including a trend term.

Table 1 summarizes the results from the lag determination tests. Looking at the FPE results, several relationships indicated the appropriate lag length was three months or less. As expected, the Schwarz criterion suggested generally lower lag lengths more in the range of one month, although it reached the identical conclusion for many relationships.[8] Results from the straightforward maximization of the adjusted R^2 were included only for comparison purposes, but notably often matched the FPE criterion.

[4] The 12 cities were Boston, Chicago, Cincinnati, Cleveland, Denver, Detroit, Los Angeles, New York, Philadelphia, Pittsburgh, St. Louis, and San Francisco.

[5] These price data were supplied by R. Buzzell of the U.S. Bureau of Labor Statistics, whose help we gratefully acknowledge.

[6] While broiler transport vehicles run mainly on diesel fuel, such a distinct series was unavailable. Graphical analyses of leaded, unleaded, and premium unleaded prices over the past decade showed strong correlation, and it was believed that diesel fuel would be similarly related. Therefore, the overall average was accepted as a suitable proxy.

[7] Other variables considered included the concentration ratio, broiler exports, broilers slaughtered, and the retail prices of beef and pork, the competing meats. Unfortunately, these variables proved too highly correlated with trend and with one another to include in the models (all correlations greater than 0.85). In addition, there were insufficient data to generate a grower input variable for buildings and equipment.

[8] To help gauge the appropriateness of the lag lengths, separate tests were performed on a weekly data set. Results suggested lags ranging primarily from three to seven weeks. Hence, we conclude the monthly lags were accurate.

Table 1. Lag Determination Test Results

Dependent Variable	Lagged Variable	Criteria: FPE Lag	Criteria: Schwarz Lag	Criteria: Adjusted R^2 Lag	Criteria: Adjusted R^2 Value
Corn	Corn	3	2	3	0.949
Soybean	Soybean	1	1	1	0.878
Farm	Farm	3	1	3	0.686
Gas	Gas	4	2	4	0.936
Wholesale	Wholesale	3	1	3	0.652
Retail (Nat)	Retail (Nat)	2	2	2	0.899
Retail (W)	Retail (W)	1	1	1	0.800
Retail (NE)	Retail (NE)	1	1	1	0.924
Retail (S)	Retail (S)	2	2	2	0.834
Retail (NC)	Retail (NC)	1	1	1	0.783
Farm	Corn	0	0	0	0.676
Farm	Soybean	0	0	0	0.683
Farm	Wholesale	1	0	1	0.979
Farm	Retail (Nat)	1	1	1	0.829
Farm	Retail (W)	3	1	3	0.747
Farm	Retail (NE)	3	1	3	0.730
Farm	Retail (S)	1	1	1	0.801
Farm	Retail (NC)	3	1	3	0.768
Wholesale	Farm	1	1	1	0.977
Wholesale	Gas	0	0	0	0.647
Wholesale	Retail (Nat)	1	1	3	0.794
Wholesale	Retail (W)	2	2	3	0.721
Wholesale	Retail (NE)	3	1	3	0.700
Wholesale	Retail (S)	4	4	4	0.766
Wholesale	Retail (NC)	3	1	3	0.745
Retail (Nat)	Farm	3	3	3	0.963
Retail (W)	Farm	4	1	1	0.847
Retail (NE)	Farm	2	2	2	0.946
Retail (S)	Farm	3	3	3	0.926
Retail (NC)	Farm	2	2	2	0.866
Retail (Nat)	Wholesale	3	3	3	0.956
Retail (W)	Wholesale	1	0	0	0.834
Retail (NE)	Wholesale	2	2	2	0.943
Retail (S)	Wholesale	3	3	3	0.917
Retail (NC)	Wholesale	2	0	2	0.853

Notes: Nat = National, W = West, NE = Northeast, S = South, and NC = North Central.

The lag tests between prices and inputs such as corn, soybeans, and gas indicated low R^2 values and zero lags. While these tests suggested the input variables were unnecessary, they were left in the asymmetry model due to the theoretical rationale for including input prices. Lag results may be due simply to the aggregated, averaged nature of the data.

Lag results were used to determine causality and asymmetry.[9] Causality results, displayed in table 2, showed wholesale prices cause farm prices and retail prices in all regions, and farm prices cause retail prices in all regions, while the retail prices in each re-

[9] The results discussed were derived using the lag results from the FPE criterion. End results from the Schwarz criterion did not vary.

Table 2. Causality Test Results

Hypothesized		
Effect	Cause	*F*-Statistic
Farm	Corn	0.427
Farm	Soybean	0.885
Farm	Wholesale	6.268*
Farm	Retail (Nat)	0.449
Farm	Retail (W)	0.754
Farm	Retail (NE)	0.372
Farm	Retail (S)	1.240
Farm	Retail (NC)	0.126
Wholesale	Farm	1.145
Wholesale	Gas	0.570
Wholesale	Retail (Nat)	0.343
Wholesale	Retail (W)	0.446
Wholesale	Retail (NE)	0.264
Wholesale	Retail (S)	1.016
Wholesale	Retail (NC)	0.685
Retail (Nat)	Farm	9.804**
Retail (W)	Farm	14.590**
Retail (NE)	Farm	19.457**
Retail (S)	Farm	13.616**
Retail (NC)	Farm	21.090**
Retail (Nat)	Wholesale	12.913**
Retail (W)	Wholesale	16.577**
Retail (NE)	Wholesale	22.995**
Retail (S)	Wholesale	18.157**
Retail (NC)	Wholesale	24.516**

Notes: Single and double asterisks (*) denote rejection of the hypothesis of no causality cause to effect at the 0.05 and 0.01 levels, respectively. Nat = National, W = West, NE = Northeast, S = South, and NC = North Central.

gion do not cause either wholesale price or farm price. The oddest of these results, the farm-to-retail link in the absence of a farm-to-wholesale link, is difficult to interpret theoretically. Unless retailers are being cautious of the potential market power of the wholesalers and check farm prices to make sure they are not being exploited, little justification can be found. This result may be a residual effect of the causality exerted on both by the wholesale price. The wholesale-to-farm and wholesale-to-retail links are consistent with increased concentration of the integrators, and conform to Ward's beliefs. Still, the market power of the integrators implied by these results may or may not be harmful, depending on the results of the asymmetry tests.

Autocorrelation proved a serious problem in conducting the asymmetry tests, with Durbin-Watson statistics from initial runs ranging from 0.5 to 0.9. Normally, this would suggest the variables should be first differenced, but this would have conflicted with the results of the unit root tests.[10] Investigating further, those variables found to have a unit root were differenced and the regressions rerun; but autocorrelation persisted. Removal of the unit root variables did improve the Durbin-Watson statistic, suggesting there may be difficulties modeling TSP and DSP variables in the same equation. In the end, autocorrelation was corrected by running the regressions as autoregressive processes of order one.

The results of the asymmetry tests for the cumulative effect, current month, and one month lagged effects can be seen in table 3. The key result was the downward price asymmetry from wholesale to farm; there was a significant difference in the effect of increases and decreases at the 0.01 level, both cumulatively and for the lagged month. It appears that integrators are not passing on price changes at the wholesale level to producers symmetrically. This implies wholesalers may be using market power in updating contract prices.

The results from the wholesale to retail levels were not consistent over the different regions, suggesting upward price asymmetry from wholesale to retail cumulative in the North Central region, cumulatively and at one month lagged on the national level, and at one month lagged in the South region, all at the 0.05 level. Curiously, despite the different conclusion from the cumulative effects, the values of the relationships in the South and the North Central regions were very close. In the Northeast and West, upward cumulative price effects were slightly higher than downward effects, but neither was significant. The West in particular showed near matching totals cumulatively and at each lag. These results add evidence to the theory of geographical market power by the integrators in the South, but suggest their power may be balanced out

[10] Unit root tests were run again, this time without a trend term, but with the same end results.

Table 3. Asymmetry Test Results

Prices		Cumulative Effect			Current Month			Previous Month		
Effect	Cause	Increase	Decrease	F	Increase	Decrease	F	Increase	Decrease	F
Farm	Wholesale	0.656	0.744	6.33**	0.640	0.652	0.01	0.016	0.092	12.0**
Retail (Nat)	Farm	1.492	1.105	4.15**	0.662	0.571	0.27	0.676	0.324	3.6
Retail (W)	Farm	1.181	0.937	1.43	0.840	0.597	0.55	0.340	0.339	0
Retail (NE)	Farm	1.430	0.923	2.55	0.595	0.436	0.31	0.725	0.401	1.6
Retail (S)	Farm	1.527	1.140	4.44**	0.677	0.520	0.51	0.860	0.272	5.9*
Retail (NC)	Farm	1.594	1.169	6.77**	0.631	0.761	0.21	0.833	0.301	2.6
Retail (Nat)	Wholesale	0.977	0.837	2.82*	0.457	0.324	0.97	0.524	0.200	5.6*
Retail (W)	Wholesale	0.771	0.735	0.18	0.498	0.433	0.08	0.280	0.302	0
Retail (NE)	Wholesale	0.886	0.725	1.18	0.323	0.309	0.01	0.565	0.258	2.6
Retail (S)	Wholesale	1.006	0.888	2.28	0.392	0.313	0.21	0.676	0.206	6.7*
Retail (NC)	Wholesale	1.055	0.890	3.38*	0.441	0.419	0.01	0.635	0.223	3.0

Notes: Single and double asterisks (*) denote rejection of the hypothesis that the effect from a price increase equals the effect from a price decrease at the 0.05 and 0.01 levels, respectively. Nat = National, W = West, NE = Northeast, S = South, and NC = North Central.

by the power of retailers in more distant markets.

Both the South and North Central regions showed significant upward asymmetry from farm to retail market levels, at the 0.01 level cumulatively, and at 0.05 for one month lagged in the South. Additionally, the national retail price also showed upward price asymmetry cumulatively at the 0.01 level. The Northeast region had a wide spread between upward and downward cumulative effects, which surprisingly failed to be significant. While other results were not significant, in most cases the F-statistic was higher than it had been in the wholesale to retail cases. It is understandable that the farm to retail results tend to be more significant than the wholesale to retail tests. As the farm level was shown to suffer downward asymmetry, and some retail prices upward, their values should be more opposed than wholesale and retail. In other words, both appear to emanate outward, oppositely, from the wholesale price.

For asymmetry tests conducted on two and three months' previous effects, there was an occasional appearance of negative coefficients, results contrary to our a priori hypotheses. Possible explanations for these include incorrect lag specification, poor model specification, multicollinearity, or insignificant effects. The problem was most pronounced at later lag periods, suggesting some lag lengths may have been overestimated.

Also not reported in table 3 was the significance of the other inputs. Coefficients on gas prices were positive for all the retail regions, but were only significant at the 0.10 level in the North Central and the West. When included nationally, gas price coefficients were negative with even lower t-statistics. The insignificance of gas prices suggests this variable has less relative importance in total costs in large portions of the country than had been hypothesized.

Corn and soybean prices typically had opposite signs from one another, and further tests indicated the coefficients were not robust. It is likely that even though these expenses are incurred by the integrators, they are still farm input costs that enter the system and are accounted for prior to the farm and wholesale price spread. Hence, corn and soybean prices were not included in the final test results reported in table 3.

As another convenient way to visualize the results, elasticities of price transmission were calculated from the asymmetry regressions. Elasticity measures for increases and decreases in the causal prices in both the short and long run are displayed in table 4. For both the

Table 4. Elasticities of Price Transmissions

Prices		Elasticity When Causal Price Is:			
		Increasing		Decreasing	
Effect	Cause	Short Run	Long Run	Short Run	Long Run
Farm	Wholesale	1.072	1.099	1.092	1.247
Retail (Nat)	Farm	0.254	0.572	0.219	0.424
Retail (W)	Farm	0.308	0.432	0.219	0.343
Retail (NE)	Farm	0.203	0.488	0.149	0.315
Retail (S)	Farm	0.281	0.633	0.215	0.472
Retail (NC)	Farm	0.255	0.644	0.308	0.472
Retail (Nat)	Wholesale	0.293	0.627	0.208	0.538
Retail (W)	Wholesale	0.305	0.473	0.266	0.451
Retail (NE)	Wholesale	0.185	0.507	0.177	0.415
Retail (S)	Wholesale	0.273	0.699	0.217	0.617
Retail (NC)	Wholesale	0.299	0.715	0.284	0.603

Notes: Nat = National, W = West, NE = Northeast, S = South, and NC = North Central.

short and long run, the decreasing wholesale price elasticities with respect to farm price exceeded those for the increasing wholesale price. Similarly, with one exception, the increasing farm and wholesale price elasticities with respect to the retail prices surpassed the respective decreasing price elasticities. In all cases, long-run elasticities appeared substantially greater than the short run, supporting the lag length test results that full price adjustments require some months.

Conclusions and Implications

The concentration and power of the integrators have allowed the wholesale price to become the center, causal price in the market. The detrimental effects of this situation, however, appear limited. For broiler growers, there are reasons for concern with downward movements in wholesale price passed on more fully to them than increases in the wholesale price. Consumers, on the other hand, are not suffering from price asymmetries. Only in the North Central region of the nation are wholesalers able to share a larger portion of their price increases with consumers than they do their price decreases. Consumer broiler prices in the Northeast even appear more affected by factors not determined by this research than by the power of the integrators.

With the changing nature of the end product in the broiler industry, consumers in fact may be more concerned with the competitiveness of price transmissions for further processed products. While the whole broiler data set used here contained both branded and unbranded prices, product differentiation is easier and more persuasive for these products. How much, then, the implications of this study carry over to such products is an open area for future research. The collection of accurate and consistent price data, especially in light of the multitude of product forms, will be the greatest hindrance to such an effort.

Based on the results, it appears evident that additional study should also be conducted on other industries exhibiting increasing concentration or other components of imperfect competition. The analytical framework identified here is an appropriate method to evaluate these price transmission relationships.

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