Price Volatility and Transmission in the Hog and Pork Markets

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Abstract

Farm, wholesale and retail price relationships in the U.S. hog sector are analyzed in this study. Estimates of price transmission indicate there is partial adjustment in each market category when there is a price change in any of the other markets. This implies that there is imperfect price transmission between the market levels. Tests of Granger no-causality show evidence of bi-directional causality in the hog and pork markets.

Keywords: causality, hogs, volatility transmission

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Price uncertainty is one of the biggest problems facing livestock producers. Prices at the wholesale and retail levels tend to be more stable than producer prices. This may be so because meatpacking and retail meat firms operate with relatively constant short run marginal costs and prices in these firms tend to be based on a proportionate marketing margin over the marginal cost. On the other hand, livestock producers are considered price takers. As such, when meat demand increases, short run output in the meatpacking and retail sectors can increase with little increase in price because of their relative output flexibility. But, at the farm level, because of the biology of the animals, short run output is more inelastic, so farm prices increase when meat demand increases.

Due to the lagged response, prices at the wholesale retail meat sectors would subsequently increase as input prices (the live animals) increase to maintain their marketing margins (Schroeder and Goodwin, 1990). Price increases at the wholesale and retail levels usually lag price increases at the farm level. Furthermore, the farm price of the live animal only makes up a small share of input into the wholesale and retail meat market. As such, knowledge of the farm-to wholesale-to retail price relationships is important for both policy and commodity market analysis.

Studies have shown that price transmission across markets does exist (Boyd and Brorsen, 1988; Hahn, 1990; Natcher and Weaver, 1999; Rezitis, 2003) and there is also evidence transmission is asymmetric. Hahn, (1990) points out that retail prices of beef and pork are more sensitive to price-increasing factors than to price-decreasing factors in the short run and that both farm and retail beef prices react more strongly to wholesale price increases than to wholesale price decreases. It is expected, then, that price transmission would reflect price volatility (month to mot price variability) as well. Transmission of price volatility across markets (from farm to wholesale to retail) suggests market inefficiency. An efficient market occurs where all information available in time *t* is reflected in current prices, but if price volatility is transmitted across markets, it would suggest that information in one market could be used to predict future prices in another market, contradicting the efficient market hypothesis. However, even efficient markets with biological lags, storage, and storage costs can exhibit a very complex price transmission dynamic.

Farm, wholesale and retail price relationships in the U.S. hog sector are analyzed in this study. The specific objective of this study was to examine price volatility and transmission from the producer to the retailer in the hog sector. Empirical results underlying the study were derived from: 1) non-parametric comparisons of volatility within each sector (farm to wholesale to retail), 2) and a complementary econometric analysis of the price transmission among the farm, wholesale, and retail markets.

Data and Empirical Methods

Data

Monthly data over the period 1970-2003 on farm prices, wholesale prices and retail prices for hogs and pork were collected from the U.S. Department of Agriculture's, National Agricultural Statistics Service (NASS) and the Economic Research Service (ERS). Choudhry (2001) used similar data in non-linear GARCH-t models to investigate seasonal anomalies but his approach does not capture monthly comparisons in volatility. Figure 1 shows the monthly price movements in the hog and pork markets since 1970. The prices in each market appear to be moving together, with wholesale prices having a steeper slope than retail and farm prices. Also, each series appears to exhibit fairly “choppy” prices throughout, suggesting a high degree of volatility.

A volatility index for each of the price series was developed using a procedure similar to Morgan (1999). A measure of the standard deviation of price variation is first developed which is:

1) $$SD_{ijt} = ((P_{itj} - P_{itj-1})^2)^{1/2}$$

where SD_{it} is the standard deviation of the price volatility in month i of year t, and P_{itj} is the price in month i for market j in year t. Equation 1 represents an index of price volatility at a particular point in time within each year t. However, to account for the annual variation in prices that does not exaggerate variation due to price trends, SD_{ijt} is divided by the average annual price, $\overline{P}_{itj}$, for each year. This serves to normalize the volatility index, giving a new variable similar to the coefficient of variation, VP_{ijt}.

2) $$VP_{ijt} = \frac{SD_{ijt}}{\overline{P}_{itj}}$$

Using this volatility index, a series of non-parametric Mann-Whitney tests were conducted by testing a series of the null hypotheses. A series of two sample tests were conducted to look at the differences in price volatility between months between markets. The validity of these tests rests on the assumption that each of the series is independent of the other. A ranked sum test between two series gives a z-value, which suggests the possibility of a rejection or acceptance of the null hypothesis. Because the Mann-Whitney test is fairly reliable for sample sizes greater than 10, it was possible to develop monthly volatility comparisons for the 34-year period studied. The monthly comparisons provide volatility evaluation above and beyond the seasonal effect.

Table 1 shows the z-scores for the matrix of monthly hog price volatility. Significant differences were seen in volatility between February and May, September and October, but for the most part there were no significant differences in monthly volatility in hog farm price. The lack of variability in hog farm price may be attributable to the high degree of organizational innovation that has taken place in hog production in terms of contract arrangement combined with specialization and technology. The coordinated production approaches where large integrators contract out production with many growers have not only allowed individual producers to become very large but may helped to create fairly stable farm prices.

Econometric Evaluation

The results presented thus far provide some partial indication that, in general, there are significant differences in volatility across hogs and pork. Further examination of price transmission and causality was carried out. First, unit root tests were conducted. When a series has a unit root, the series is nonstationary and the OLS estimator is not normally distributed. Based on the Johansen cointegration rank test, the farm, wholesale and retail price series were cointegrated with a rank of 2 with a *p*-value of 0.0294 (5 % significance level). The tests also indicate a separate drift and no separate linear trend, thereby requiring the following vector error correction modeling (VECM) form:

3) $$\Delta fp_t = \sum_i (a_{1i} fp_{t-i} + a_{1i} wp_{t-i} + a_{1i} rp_{t-i}) + \sum_i (a_{1i} \Delta fp_{t-i} + a_{1i} \Delta wp_{t-i} + a_{1i} \Delta rp_{t-i}) + \varepsilon fp_t$$

4) $$\Delta wp_t = \sum_i (b_{1i} fp_{t-i} + b_{1i} wp_{t-i} + b_{1i} rp_{t-i}) + \sum_i (b_{1i} \Delta fp_{t-i} + b_{1i} \Delta wp_{t-i} + b_{1i} \Delta rp_{t-i}) + \varepsilon wp_t$$

5) $$\Delta rp_t = \sum_i (c_{1i} fp_{t-i} + c_{1i} wp_{t-i} + c_{1i} rp_{t-i}) + \sum_i (c_{1i} \Delta fp_{t-i} + c_{1i} \Delta wp_{t-i} + c_{1i} \Delta rp_{t-i}) + \varepsilon rp_t$$

where *fp*, *wp*, and *rp* are the farm, wholesale, and retail prices for the hog and pork market and Δfp, Δwp, and Δrp are first differences of the respective prices, and $\varepsilon fp_t, \varepsilon wp, and \varepsilon rp$ are residuals of the farm, wholesale, and retail prices, respectively.

The maximum likelihood estimates of the VECM applied to the hog and pork markets are reported in Table 2 and the price transmission impacts are reported in Table 3. The statistical significance of the coefficients suggests that participants at each market use information from the other market levels to form output price expectations.

Estimates of price transmission in Table 3 are calculated based on Rezitis (2003). The estimates indicate there is partial adjustment at each market level when there is a price change in any of the other levels. This implies that there is imperfect price transmission between the markets. Estimated prices transmission impacts were lowest at the wholesale level. This suggests that price changes at the wholesale level had very little effect on either the retail or the farm level prices. Also, the estimated impact of price transmission from farm to wholesale was not equivalent to the estimated transmission from wholesale to farm. This was true for the other market levels, as well, suggesting asymmetry in price transmission. This is consistent with findings Hahn (1990) using another approach.

Causality Between Markets

The preceding results give a reasonable account of the relationships between volatility and price levels at different time periods, but provide no information on causality. In this section causality within hog and pork markets is evaluated to see whether it exists, and if so, whether it is unidirectional, or bi-directional in nature among the three markets. Granger (1969) defined causality in a way that facilitates empirical testing. He assumed that the variables being tested result from a stochastic process; that the series are stationary; and that the future cannot be predicted by the past. This suggests that price changes will occur only when new and unanticipated information enters the market. The existence of vertically integrated levels within sectors, such as the relationship between farm, wholesale, and retail levels of the hog and pork sector presents a situation where this type of causal relationship can be tested.

Shan and Papas (2000) suggest that the Granger no causality procedure in multiple time series is fraught with problems. They point out that the F-test, in the regression context for determining whether some parameters of a model are jointly zero, (for example, in the form of a causality test in a stable vector autoregressive (VAR) model), is not valid when variables are integrated (Gujarati's 1995). To improve on Granger's approach, Toda and Yamamoto (1995) used the parameters of the VAR(k) where k is the lag length in the system. Their test has an asymptotic ι^2 distribution when a VAR($k+d_{max}$) is estimated where d_{max} is the maximum order of integration suspected in the system.

The results for the Granger no-causality test are presented in Table 4. The hypotheses that the price in one market does not "cause" the price in the other markets were rejected at the 1 percent significance level for most of the pairwise comparisons. Only farm price did not appear to cause retail pork price, a result suggesting that irrespective of the price changes at the farm level, there would be little influence at the retail level. However, for the most part the results also show evidence of bi-directional causality.

Conclusions

The objective of this paper was to examine price volatility and price transmission in the hog and pork sector. An index that provides measures of price volatility for vertically integrated markets in the hog and pork sector was developed. Non-parametric comparisons of volatility within (farm to wholesale to retail) each market were used to evaluate the influence of the month (season) on volatility.

The empirical evidence suggests that cointegration exists between the hog and pork markets that warrant a vector error correction model (VECM) econometric analysis. Price transmission impacts and causality were evaluated. The estimates indicate that there is partial adjustment in each market category when there is a price change in any of the other markets which implies that there is imperfect price transmission between the markets. The results also suggest significant causality in price transmission within the hog sector.

Price volatility and transmission are of particular interest to the livestock industry. A sector with no direct ties to farm programs is always concerned about price volatility since most farm programs are geared to stabilizing price variation. Also, because livestock insurance is still in its infant stages, the livestock sector is highly exposed to seasonality and shocks. Testing for price transmission impacts and causality is also advantageous because it allows the researcher to make inferences about the structure of vertically integrated livestock systems.

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Figure 1. Farm, wholesale, and retail price movements for hogs and pork

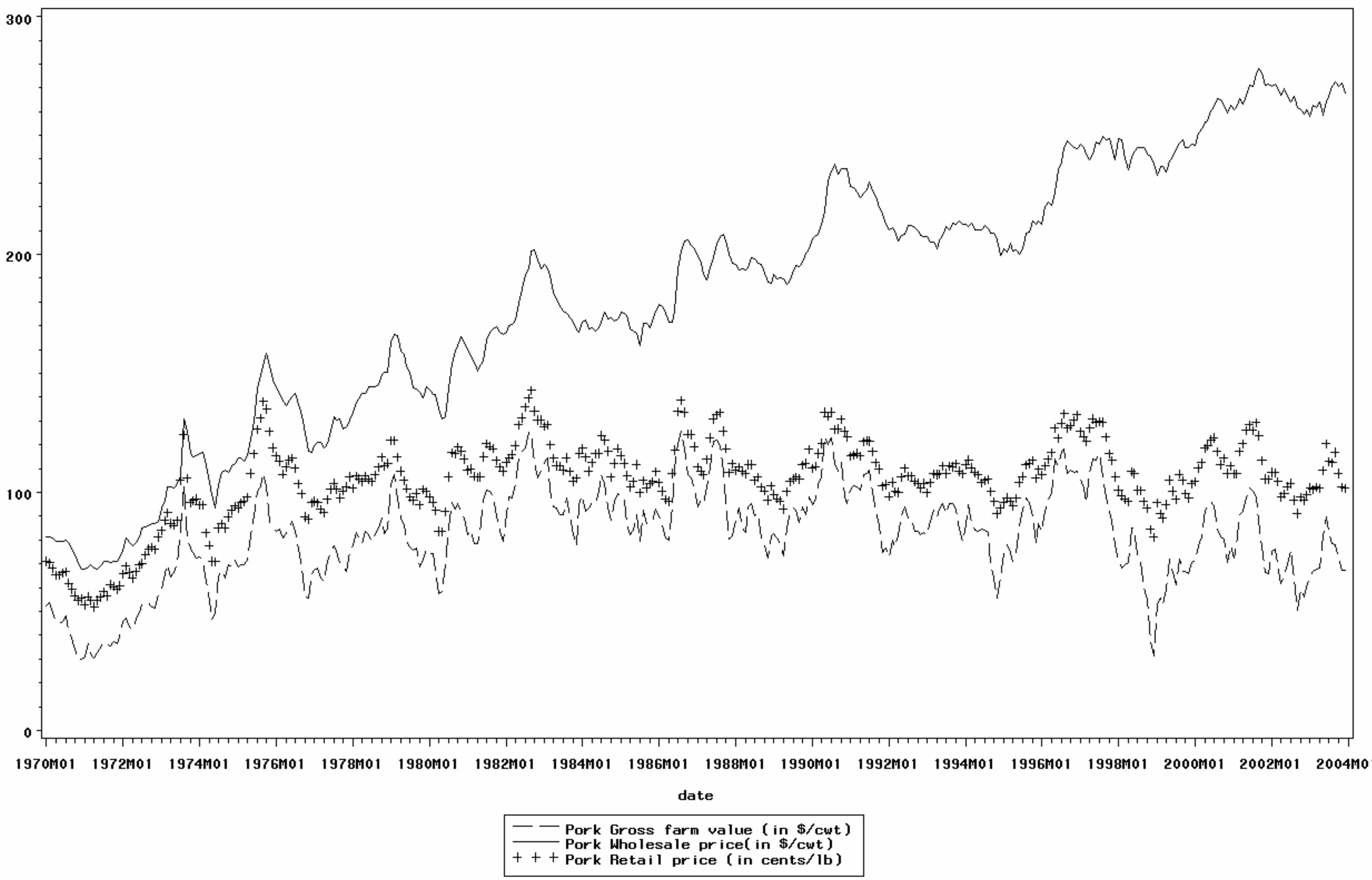

Table 1. Z-scores for monthly hog farm price volatility matrix

Month	Mean Volatility	February	March	April	May	June	July	August	September	October	November	December
January	1.556	0.77	-0.73	0.27-	-1.36	-0.069	-0.51	-0.33	-0.98	-0.96	-0.63	-0.19
February	1.22		-1.56	-0.59	-2.34**	-0.93	-1.42	-1.09	-2.13**	-1.98*	-1.56	-1.23
March	1.401			0.82	-1.06	0.48	-0.10	0.15	-0.48	-0.30	-0.21	0.37
April	1.465				-1.69*	-0.40	-0.80	-0.56	-1.32	-1.13	-0.91	-0.37
May	1.426					1.30	0.82	0.98	0.51	0.84	0.68	1.39
June	1.482						-0.46	-0.30	-0.99	-0.80	-0.63	-0.15
July	1.507							-0.23	-0.57	-0.29	-0.10	-0.28
August	1.346								-0.57	-0.34	-0.37	0.21
September	1.309									0.26	0.28	0.85
October	1.308										-0.02	0.64
November	1.188											0.58

**Significant at the 5 percent level
*Significant at the 10 percent level

Table 2. Maximum likelihood estimates of a VECM of the hog and pork markets

Δfp – Hog farm price equation		Δwp – Hog wholesale price equation		Δrp – Hog retail price equation	
Coefficients	Estimates	Coefficients	Estimates	Coefficients	Estimates
Constant	3.4788	Constant	-0.1457	Constant	6.4786
	(2.5061)		(1.2329)		(1.9116)
a_{11}	-0.0771	b_{11}	0.0266	c_{11}	0.0507
	(0.0518)		(0.0255)		(0.0395)
a_{12}	0.0048	b_{12}	-0.0007	c_{12}	0.0109
	(0.0044)		(0.0022)		(0.0034)
a_{13}	0.0203	b_{13}	-0.0142	c_{13}	-0.1189
	(0.0659)		(0.0324)		(0.0502)
a_{21}	0.3434	b_{21}	0.1309	c_{21}	0.1944
	(0.1030)*		(0.0507)*		(0.0786)*
a_{22}	-0.2942	b_{22}	0.0268	c_{22}	-0.1441
	(0.0984)*		(0.0484)		(0.0751)
a_{23}	-0.0157	b_{23}	0.2616*	c_{23}	0.0699
	(0.1412)		(0.0695)		(0.1077)

Figures in parenthesis denote standard errors and * denotes significance at the 1% level.

Table 3. Price transmission impact

	Estimated Impact
Farm level	
From hog farm price to hog wholesale price a21/1+a22	0.265
From hog farm price to hog retail price a21/1+a23	0.338
Wholesale level	
From hog wholesale price to hog farm price b22/1-b21	0.031
From hog wholesale price to hog retail price b22/1-b23	0.036
Retail level	
From hog retail price to hog farm price c23/1-c21	0.087
From hog retail price to hog wholesale price c23/1+c22	0.061

Table 4. Granger-Causality Wald Test for hog and pork markets

	Lagged effect	
	Chi-Square	*Pr >Chi-Square*
Hog sector prices		
Farm *cause* wholesale	0.0054	0.0054***
Farm *cause* retail	0.4432	0.4432
Wholesale *cause* farm	0.0001	0.0001***
Wholesale *cause* retail	0.0001	0.0001***
Retail *cause* farm	0.0092	0.0092***
Retail *cause* wholesale	0.0837	0.0837*

***Significant at the 1 percent level
*Significant at the 10 percent level