Price Volatility and Futures Market Reactions to USDA Hogs and Pigs Report

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PRICE VOLATILITY AND FUTURES MARKET REACTIONS TO USDA HOGS AND PIGS REPORT

Satheesh V. Aradhyula, T. Kesavan, and Matthew T. Holt[1]

Background

The United States Department of Agriculture (USDA) releases the *Hogs and Pigs Report* (HPR) in March, June, September, and December[2] of each year in regularly scheduled and widely publicized announcements. The HPR contains estimates of breeding herd inventories, market hogs and pigs inventories by weight group, pig crop, pigs per litter, and producers' sow farrowing intentions for the next two quarters.

The HPR is released around 3 p.m. in the afternoon after futures trading has closed for the day. The contents of these reports are secretly held by the USDA until they are released and there usually is a great anticipation among farmers and farm commodity traders regarding the contents of the HPR. The HPR is widely considered to be among the most important sources of information for producers and futures traders.

Recent literature in agricultural economics has devoted much attention to analyzing the informational content of HPRs, whether HPR constitutes "news," and the effects of HPR release on the movement of live hog futures prices. Miller examined the release of 36 HPRs (from September 1970 through June 1978) by focusing on price changes one day before and after the release of reports. Using ordinary least squares with the change in daily futures prices around the reports as the dependent variable, Miller found that both nearby and distant live hog futures reacted significantly to the information contained in HPRs. Hoffman investigated the effects of HPRs (March 1970 through 1979) on hog prices by comparing five-day average prices before and after the release of HPRs. Using these weekly average prices in a regression framework, Hoffman found that both nearby and more distant futures contracts for hogs did not respond significantly to quantity information released in reports.

Hudson, Knootz and Purcell examined the live hog futures price changes for 40 day periods around the release day of HPRs (March 1974 through December 1982) and concluded that live hog futures prices "adjust to new information in the Hogs and Pigs Reports rapidly and, in general, move in the appropriate direction." Using live hog futures price data from 1971 - 1985, Carter and Galopin tested all variables in HPR for their effects on the futures market. They identified breeding herd, market herd under 60 pounds, and pig crop as critical variables in the HPR that cause price movements in the

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[2]Starting with the January 1989 report, the fourth quarter report is released in January.

nearby and distant futures prices. They conclude that HPRs contain news that market traders are unable to anticipate prior to the HPR release. Like previous event studies, Carter and Galopin do not account for Heteroskedasticity in futures prices and thus, do not investigate if HPRs have any influence on the volatility of the futures prices.

In a recent study Colling and Irwin use market survey data as a proxy for anticipated information to test the hypothesis of market efficiency for the live hog futures market. Using a two-limit Tobit model to explicitly account for institutional price limits, they find evidence in support of the efficient market hypothesis in that live hog futures prices: (a) do not react to anticipated information contained in HPR; (b) do react significantly and in the expected direction to unanticipated information in HPR, and; (c) generally adjust to unanticipated information on the day following release of the reports.

In addition to these studies that focused on the HPR, there is a vast literature that deals with other USDA reports and the effects of news on the stock market in general. Barnhart (1989) examined the effects of macroeconomic announcements on several futures prices. The effects of USDA *Crop Production* reports on cash and futures prices for grains and soybeans have been analyzed by Fackler, Fortenbery and Sumner, Milanos, and Sumner and Mueller. Schroeder et al. examined the impact of the *Cattle on feed* report. These studies make important contributions and indicate that, in general, USDA releases do have an impact on the movements of futures prices. However, these studies (with the exception of Sumner and Mueller) limit the analysis to the mean of futures prices only. In particular, they do not examine the impacts of the government announcements on the volatility of futures prices.

Price volatility is an important issue, because for a risk avert agent, both mean and variance of price are important. This paper investigates the effects of HPR releases on the mean *and* the conditional variance of live hog futures prices. The specific objective of the study is to determine if the release of the HPR by USDA has any influence on the volatility of live hog prices. Using a generalized autoregressive conditional heteroskedasticity (GARCH) time series processes, the present study attempts to measure the effects of HPR on the movements of futures market prices for live hogs traded at the Chicago Mercantile Exchange (CME). Unlike previous studies which limited their analysis to price movements only, this paper also addresses the price volatility implications of USDA reports.

Data and Methodology

The data for the present study consists of daily settlement prices for the seven live hog futures (February, April, June, July, August, October, and December) that expired in 1990. Data on settlement prices are obtained from CME. The analysis is carried out separately for each contract using all the observations spanning the life of the contract. Depending on the contract, the time period for the analysis ranges from January 1989 to December 1990. Also, since each contract is traded for a different number of days, the number of observations used for each contract is different (Table 1). The present study does not classify contracts into nearby and distant contracts. All contracts are treated similarly and the analysis is carried out individually for each contract. Finally, unlike previous studies, we do not create an artificial "nearby futures contract" by splicing data from various individual contracts. This splicing makes the resulting synthetic time series discontinuous and generally contains jumps at the point of switching.

To examine the effects of HPRs on futures price volatility, we use a GARCH-M time series process. Let ε_t denote a real valued discrete-time stochastic process and I_t the set of all information available through time period t. The GARCH(p,q) process for a normal conditional distribution is then given by:

(1) $$\varepsilon_t | I_t \sim N(0, h_t),$$

(2) $$h_t = a_0 + \sum_{i=1}^{q} a_i \varepsilon_{t-i}^2 + \sum_{i=1}^{p} b_i h_{t-i}$$

where, $p \geq 0$, $q \geq 0$, $a_0 \geq 0$, $a_i \geq 0$, $b_j \geq 0$, $i = 1, \ldots, q$, and $j = 1, \ldots, p$. Note for p=0, the process reduces to an ARCH(q) process. Also, for p=q=0 the conditional variance is constant, as is in typical time-series models, and the innovation ε_t simply reduces to white noise. The GARCH(p,q) regression model can be obtained by letting the ε_t's be innovations in a linear regression,

(3) $$\varepsilon_t = y_t - x_t'\beta,$$

where y_t is the dependent variables, x_t is a vector of observations on explanatory variables including past realizations of y_t, and β is vector of unknown parameters to be estimated. The GARCH specification is ideal to examine the effects of new information, because it explicitly allows for capturing movements in both the mean and conditional variance of price.

If the vector x_t contains h_t, then the process consisting of equations (1) - (3) is called a GARCH-M process. A GARCH-M term is generally included to capture any time-varying risk-premium. In this study a GARCH-M process is used to model live hog futures prices. Additionally, a dummy variable D_{jt}, which takes a value of 1 on j^{th} day after HPR release and zero otherwise, is used as an additional explanatory variable in equation (2). Finally, before a GARCH model is fitted, time series properties of the price series are first examined by testing for the non-stationarity (presence of unit root).

Results

Average changes in live hog futures prices for the seven live hog contracts are reported in Table 1. When HPRs are released, the price of all seven futures contracts moved in the same direction but not always by the same amount (Table 1). The CME live hog futures moved to the limit ($1.50) about 50% of the time following the release of HPR by USDA.

The average absolute change in live hogs futures price over the life of the contract ranged from 29 cents for April 1990 contract to 38 cents for the December 1990 contract. The average change following the release of HPR ranged from 99 cents for February and August 1990 contract to a high of $1.48 for the December contract. Futures prices changed by about three times as much on the day after an HPR release compared to other days. Thus, there is a considerable movement in the live hog futures prices following the release of HPR. Though there is greater movement on the second day after HPR release relative to non-announcement days, the difference is much smaller. Price changes on the second day averaged 51 cents compared to a life time average change of 34 cents. It appears, most information in the HPR is absorbed by the market by the end of next day.

Before estimating any time series model, the time series properties of the data should be examined. The finding of a unit root in a time series indicates nonstationarity which has implications for both economic theory and econometric modeling. The presence of unit root in economic time series is commonly tested by means of Dickey-Fuller or augmented Dickey-Fuller tests (see Dickey and Fuller; Fuller; and Perron). Recently, Phillips (see also Phillips and Perron) derived testing procedures for the unit root hypothesis under more general conditions. In this study, these tests developed by Phillips, and Phillips and Perron, are applied to each price series.

The calculated test statistics for the presence of a unit root in the futures price series are presented in Table 2. If the value of the calculated test statistic is smaller than the critical value, the null hypothesis of a unit root cannot be rejected. The critical values at 10% level of significance are reported at the bottom of Table 2. Only three of the 42 test statistics reported are significant at 10% level. Thus, the null hypothesis that futures prices have a unit root cannot be rejected for all seven contracts. The tests are then repeated (not reported here) on the first differences and the null that ΔP_t has a unit root is rejected for each series.

As a result of the above tests, all prices are first-differenced before any time series models are fitted. Initially, simple autoregressive (AR) models are fitted for ΔP_t to identify appropriate lag lengths. Ljung-Box Portmanteau statistics for serial correlation in fitted residuals are computed to validate the estimated model. Results for all seven contracts indicated that fitted ε_t are white noise (calculated Q statistic is smaller than the critical value). However, Q^2 statistics for testing correlation in $\hat{\varepsilon}_t^2$ present a different picture. The calculated Q^2 statistics for all seven contracts were found to be statistically significant, indicating that a GARCH specification might be appropriate.

For each price series, GARCH(1,1) models were estimated first because they are parsimonious and are often the most likely candidates in applied analysis (Bollerslev). If these initial GARCH(1,1) estimates are not satisfactory, alternative specifications of the conditional variance equation, h_t, were examined. Following this procedure, it was determined that GARCH(1,1) process was adequate for explaining the conditional variances of February, April, July, August, October, and December 1990 contract. On the other hand, an ARCH(5) specification was found to be more suitable for the June 1990 live hog futures price. Maximum likelihood estimates of GARCH-M models for the seven live hog contracts are presented in Table 3[3].

The Q and Q^2 statistics for the standardized fitted innovations from the estimated GARCH-M and ARCH-M models are given in Table 3. All the reported Ljung-Box Q^2 statistics, except for the July contract, are statistically insignificant at 5% level. The Q^2 for the July contract was found to be insignificant only at 10% level. The results of these Ljung-Box statistics indicate that no further first- or second-order serial dependence is indicated in the estimated GARCH-M and ARCH-M models, that is, there are no further exploitable linear relations in the residuals and squared residuals, and the fitted GARCH-M and ARCH-M models are adequate.

However, results with respect to the risk premium term are mixed. The GARCH-M term is significant at the 5% level[4] only for the April contract. Two other contracts (July and October) have GARCH-M terms that are significant at the 10% level. When all contracts are considered, the GARCH-M terms appear not to be significant. These results are consistent with those reported in Yang and Brorsen.

All the coefficients in the h_t equations are positive and the a_i and b_i coefficients add to less than unity, thus ensuring that the underlying unconditional variances are finite. Also, in each h_t equation, a_0, a_i and b_i parameters are significant at the 5% level. The HPR dummy, D_{1t}, has a positive sign in all seven conditional variance equations and is significant at 5% confidence level for the February, April, October and December contracts. In July and August contracts the t values associated with D_{1t} are 1.654 and 1.945 which are greater than the critical value of 1.645 at 10% level of confidence. The D_{1t} term in June contract has a t-value of 1.565. In general, the results in Table 3 indicate that D_{1t} is a significant variable affecting the conditional variance of live hog futures prices.

The significant D_{1t} in a GARCH conditional variance equation implies that conditional variances for live hog futures vary over time during the life of the contract and these conditional variances are significantly higher on the day after the release of the HPRs. This constitutes an indirect test for the significance of the release of the HPR on the futures price volatility. Another important implication of significant GARCH coefficients (b_i) is that volatility changes are persistent since a non-zero b_i in equation (3) implies an infinite memory. This persistence in price volatility is highlighted in Table 4.

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[3]Institutional price limits are not accounted for in the estimation of the GARCH models since the number of observations with limit moves are deemed very low (an average of 6 limit observations) relative to the total number of observations (an average of 286). Thus, our results may under estimate the significance of announcement effects. Additionally, market anomalies such as day-of-the-week effect and seasonality are not explored in the present study.

[4]One tail test with the alternative hypothesis that GARCH-M term is positive.

Table 4 presents conditional variances of the futures prices calculated at various points during the life of each contract. The average h_t over the life of a contract varied from 0.167 for February to 0.288 for the December. The average h_t on the day after the release of HPR ranged from 0.352 for the July contract to 1.371 for the June contract. For each contract, the h_t on the day after HPR release is higher than the average h_t over the life of the contract. In fact, except for the October contract, h_t on the day after was at least twice as high compared to the average lifetime h_t. Thus, the release of HPRs seem to increase the volatility of the futures market. This increase in price volatility is persistent as evidenced by higher than usual h_t's for the second and third day after the release of HPRs. This persistence in price volatility is not as noticeable in the June contract. Of course, this is what one would expect given an ARCH specification for the June contract (as Opposed to a GARCH). Thus, it appears there is some unanticipated information in the HPRs and this unanticipated information leads to a higher variance in the futures prices around the release dates.

Conclusions

In this paper, we investigated the effects of USDA *hogs and pigs report* on the volatility of futures prices for live hogs. A Generalized Autoregressive Conditional Heteroskedasticity framework is used to capture these volatility effects of *hogs and pigs report*. It appears that HPRs contain news that market traders are unable to anticipate prior to the HPR release. Results indicate that HPR significantly influences the volatility of live hog futures prices and that futures prices are more volatile around the release day HPRs. Additionally, these volatility effects are persistent in nature and last more than one day.

A few caveats are in order. The sample period in the present study extends only over two years. Analysis should be carried out for futures contracts in other years before the robustness of the present results can be established. Volume of trade, especially in options market, is believed to indicate riskiness of the underlying futures. It might, therefore, prove to be useful to consider volume data in analyzing the volatility implications of the HPR release. Finally, it would be interesting to see the nature of the response of futures prices for pork bellies to HPR release. These are some of the issues which should be pursued in future research.

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Table 1: Live Hog Futures Price Changes Following Release of Hogs and Pigs Report, 1989-1990.

	Futures Contract Expiring in 1990						
	Feb	**Apr**	**Jun**	**Jul**	**Aug**	**Oct**	**Dec**
No. of Observations	286	287	295	274	274	296	293
No. of Times Price Limits Are Hit	2	2	8	8	9	8	5
Price Change on the trading day after HPR Release ($/cwt):							
HPR Relase Date							
Jan 6, 1989	0.30						
Mar 31, 1989	-1.00	-1.37					
June 30, 1989	-1.50	-1.50	-1.50	-1.50			
Sept 29, 1989	0.65	0.63	0.32	0.30	0.10	-0.30	
Jan 3, 1990	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Mar 30, 1990		0.87	1.45	1.42	1.50	1.50	1.50
June 29, 1990				0.87	0.87	1.30	1.40
Sept 28, 1990						1.50	1.50
Average Absolute Change	0.99	1.17	1.19	1.12	0.99	1.22	1.48
Average Absolute Change on Second Day After HPR Release	0.34	0.39	0.63	0.71	0.53	0.44	0.51
Average Absolute Change Over the Life of Contract	0.30	0.29	0.31	0.36	0.35	0.36	0.38

Table 2: Phillips-Perron Tests for Unit Roots in Live Hog Futures Prices

$$P_t = \hat{\alpha} P_{t-1} + \hat{u}_t$$
$$P_t = \mu^* + \alpha^* P_{t-1} + u_t^*$$
$$P_t = \tilde{\mu} + \tilde{\beta}(t - T/2) + \tilde{\alpha} P_{t-1} + \tilde{u}_t$$

	Statistics					
	$Z(t_{\hat{\alpha}})$	$Z(t_{\alpha^*})$	$Z(\phi_1)$	$Z(t_{\tilde{\alpha}})$	$Z(\phi_2)$	$Z(\phi_3)$
Null Hypothesis:	$\hat{\alpha}=1$	$\alpha^*=1$	$\alpha^*=1$; $\mu^*=0$	$\tilde{\alpha}=1$	$\tilde{\alpha}=1$; $\tilde{\beta}=0$	$\tilde{\alpha}=1$; $\tilde{\beta}=\tilde{\mu}=0$
<u>Futures Contract</u>:						
February	0.53	-1.31	1.03	-1.83	1.34	1.85
April	1.82*	1.78	3.44	0.04	3.94	3.92
June	1.40	-0.24	1.06	-1.89	2.12	2.11
July	1.81*	0.25	1.65	-2.70	4.09	4.50
August	1.23	-0.95	1.35	-1.67	1.53	1.50
October	1.64*	-0.80	1.80	-2.18	2.58	2.40
December	0.51	-2.03	2.25	-2.09	1.89	2.63
90% CV	-1.62	-2.57	3.81	-3.13	4.07	5.39

Note: An asterisk denotes significance at the 90% level. 90% CV's are the tabled critical value at the 90% level.

Table 3. Maximum Likelihood Estimates of GARCH-M Models Fitted

February, 1990 Futures Contract:

$$\underset{(2.011)}{(1+0.123\,B^{7}}\;\underset{(3.144)}{+\,0.189\,B^{14})}\;\Delta P_{1t} = \underset{(0.670)}{0.097\,h_{1t}} + \varepsilon_{1t} \qquad Q(24)=20.67$$

$$h_{1t} = \underset{(2.604)}{0.056} \underset{(2.307)}{+\,0.010\,\varepsilon_{1t-1}^{2}} + \underset{(16.848)}{0.862\,h_{1t-1}} \underset{(2.420)}{+\,0.285\,D_{1t}} \qquad Q^{2}(24)=15.06$$

April, 1990 Contract:

$$\underset{(3.181)}{(1-0.151\,B^{12}}\;\underset{(5.399)}{+\,0.234\,B^{14})}\;\Delta P_{2t} = \underset{(1.857)}{0.228\,h_{2t}} + \varepsilon_{2t} \qquad Q(24)=19.38$$

$$h_{2t} = \underset{(2.436)}{0.073} \underset{(3.488)}{+\,0.285\,\varepsilon_{2t-1}^{2}} + \underset{(11.314)}{0.685\,h_{2t-1}} \underset{(2.396)}{+\,0.414\,D_{1t}} \qquad Q^{2}(24)=19.39$$

June, 1990 Contract:

$$\underset{(1.026)}{(1-0.073\,B^{5}}\;\underset{(0.539)}{-\,0.031\,B^{11})}\;\Delta P_{3t} = \underset{(1.244)}{0.167\,h_{3t}} + \varepsilon_{3t} \qquad Q(24)=21.45$$

$$h_{3t} = \underset{(16.240)}{0.307} \underset{(2.723)}{+\,0.136\,\varepsilon_{3t-1}^{2}} + \underset{(2.956)}{0.252\,\varepsilon_{3t-5}^{2}} \underset{(1.565)}{+\,1.264\,D_{1t}} \qquad Q^{2}(24)=18.85$$

July, 1990 Contract:

$$\underset{(1.212)}{(1-0.082\,B}\;\underset{(2.140)}{+\,0.141\,B^{3}}\;\underset{(2.078)}{-\,0.113\,B^{15})}\;\Delta P_{4t} = \underset{(1.089)}{0.004} + \underset{(1.301)}{0.280\,h_{4t}} + \varepsilon_{4t} \qquad Q(24)=26.36$$

$$h_{4t} = \underset{(3.639)}{0.136} \underset{(2.921)}{+\,0.203\,\varepsilon_{4t-1}^{2}} + \underset{(6.456)}{0.682\,h_{4t-1}} \underset{(1.654)}{+\,0.398\,D_{1t}} \qquad Q^{2}(24)=36.17$$

August, 1990 Contract:

$$(1-0.092\,B\ +0.148B^3-0.029\,B^5)\,\Delta P_{5t}=0.070-0.103\,h_{5t}+\varepsilon_{5t} \qquad Q(24)=18.55$$
(1.141) (2.312) (0.451) (2.366) (0.622)

$$h_{5t}=0.058\ +0.185\,\varepsilon_{5t-1}+\ 0.804\,h_{5t-1}+0.228\,D_{1t} \qquad Q^2(24)=25.32$$
(2.266) (3.474) (14.787) (1.945)

October, 1990 Contract:

$$(1-0.191\,B\ +0.121B^2)\,\Delta P_{6t}=0.169h_{6t-1}+\varepsilon_{6t} \qquad Q(24)=20.12$$
(3.039) (1.864) (1.483)

$$h_{6t}=0.059\ +0.120\,\varepsilon_{6t-1}+\ 0.850\,h_{6t-1}+0.280\,D_{1t} \qquad Q^2(24)=9.76$$
(2.634) (2.978) (18.161) (2.383)

December, 1990 Contract:

$$(1-0.123\,B\ +0.098B^2)\,\Delta P_{7t}=0.079h_{7t}+\varepsilon_{7t} \qquad Q(24)=19.88$$
(1.793) (1.457) (0.790)

$$h_{7t}=0.068\ +0.137\,\varepsilon^2_{7t-1}+\ 0.837\,h_{7t-1}+0.432\,D_{1t} \qquad Q^2(24)=23.41$$
(2.260) (2.094) (11.856) (2.162)

Notes: B is a lag operator such that $B^sX_t=X_{t-s}$ and Δ is a first difference operator. Figures in parentheses are approximate absolute t-ratios. Q(k) and $Q^2(k)$ denote Ljung-Box Portmanteau test statistics for serial correlation in $\hat{\varepsilon}_t$ *and* $\hat{\varepsilon}_t^2$, respectively, at k degrees of freedom. The value of X^2 distribution at 24 degrees of freedom at the 10% (5%) level of significance is 33.2 (36.4).

Table 4: HPR Release and Average Conditional Variance (h_t) in Live Hog Futures Prices.

	Futures Contract Expiring in 1990						
	Feb	Apr	Jun	Jul	Aug	Oct	Dec
Average h_t on 1st day after HPR release	0.368	0.542	1.371	0.521	0.352	0.438	0.585
Average h_t on 2nd day after HPR release	0.456	0.801	0.336	0.559	0.505	0.541	0.751
Average h_t on 3rd day after HPR release	0.408	0.591	0.189	0.472	0.488	0.489	0.663
Average h_t over the life on the contract	0.167	0.176	0.185	0.214	0.267	0.251	0.288
Unconditional Variance	2.000	2.433	0.618	1.183	5.273	1.967	2.615