*Journal of Agricultural and Resource Economics* 31(2):262–282


# The Value of USDA Situation and Outlook Information in Hog and Cattle Markets

**Olga Isengildina, Scott H. Irwin, and Darrel L. Good**

This study investigates the impact of six major USDA reports in hog and cattle markets: Cattle; Cattle on Feed; Cold Storage; Hogs and Pigs; Livestock, Dairy, and Poultry Outlook (LDPO); and World Agricultural Supply and Demand Estimates (WASDE). A TARCH-in-mean model, with dummy variables to measure the impact of USDA reports and other external factors, is used to model close-to-open live/lean hog and live cattle futures returns from January 1985 through December 2004. The analysis revealed a statistically significant impact of all but Cattle and Cold Storage reports in live/lean hog futures, and all but Cold Storage reports in live cattle futures. Hogs and Pigs reports had the highest impact on live/lean hog returns by increasing conditional standard deviation 96%. Cattle, Cattle on Feed, and Hogs and Pigs reports had the highest impact on live cattle returns by increasing conditional standard deviation between 26% and 37.5%.

*Key words:* cattle, event study, hogs, livestock, public information, TARCH model, USDA reports

## Introduction

The economic value of public situation and outlook information has long been a subject of debate. This debate has become more intensive in recent years for several reasons, including the changing structure of agriculture, the growth of private firms that provide relatively low-cost information and market analysis of the type traditionally offered by public programs, and evolving priorities within the USDA. Quite pointedly, Just (1983) argued that public situation and outlook programs should be downsized or eliminated because private firms perform the functions historically provided by public programs. Salin et al. (1998) more recently set forth the following strong challenge to public programs: "If public information simply replicates what is known and disseminated in the private sector, then the public sources are superfluous and might be eliminated. As proprietary data play an increasingly central role in agricultural decision making, the public sector niche in the market for agricultural information must be reconsidered" (p. 122).

---

Olga Isengildina is a post-doctoral researcher with the AgMAS Project, Scott H. Irwin is the Laurence J. Norton Professor of Agricultural Marketing, and Darrel L. Good is a professor, all in the Department of Agricultural and Consumer Economics, the University of Illinois at Urbana-Champaign. The funding support of the U.S. Department of Agriculture's Economic Research Service, under Cooperative Agreement No. 43-3AEK-8-80115, is gratefully acknowledged. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the U.S. Department of Agriculture. The authors thank Wade Brorsen and two anonymous reviewers for their valuable comments.

Review coordinated by DeeVon Bailey.

In response to this ongoing debate, several empirical studies have investigated the economic benefits of public information in agricultural markets (e.g., Sumner and Mueller, 1989; Colling and Irwin, 1990; Fortenbery and Sumner, 1993; Grunewald, McNulty, and Biere, 1993; Baur and Orazem, 1994). Most of these empirical studies use a variant of event study methodology. The basic notion of an event study is simple: If prices react to the announcement of information ("the event") in an efficient market, then the information is valuable to market participants (Campbell, Lo, and MacKinlay, 1997). With only a few exceptions, event studies report a significant market price reaction to the release of USDA reports, suggesting that public information released by USDA generates economic welfare benefits (Falk and Orazem, 1985).

The most significant limitation of the existing literature on the value of public information is that previous studies conduct a report-by-report analysis in a piecemeal fashion, not allowing for comparison of impacts across relevant reports. While most of these earlier works apply an event study approach, different methods and sample periods are utilized. Consequently, it is difficult to compare results across studies. Furthermore, limited information is available about the value of the outlook component of USDA reports. Adopting the terminology of Just et al. (2002), the situation component generates relatively unprocessed or raw statements of fact ("data"), while the outlook component produces analysis, synthesis, and interpretative reports ("information"). The focus of most previous studies has been on the value of situation reports, with only a few (e.g., Fortenbery and Sumner, 1993) also analyzing the outlook component. Moreover, there is often little emphasis on the magnitude of market impacts, as most earlier investigations have concentrated on qualitative "yes"/"no" conclusions about the impact of public information. Finally, careful attention has not been paid to the issue of "clustering" (simultaneous release of several reports) on particular days or during the same reaction window. Given the availability of multiple reports for most commodities, clustering can pose a serious problem that may undermine the findings of earlier studies.

The above limitations of the existing literature demonstrate a need for a more comprehensive investigation. Toward this end, the specific purpose of this study is to investigate the impact of all major USDA situation and outlook announcements in hog and cattle futures markets from 1985 through 2004. To our knowledge, this is the first analysis to simultaneously consider the market impact of all major public information reports in a commodity market.

The investigation uses an event study approach, with the events consisting of the release of six major USDA situation and outlook reports for hogs and cattle: (*a*) Cattle; (*b*) Cattle on Feed; (*c*) Cold Storage; (*d*) Hogs and Pigs; (*e*) Livestock, Dairy, and Poultry Outlook (LDPO); and (*f*) World Agricultural Supply and Demand Estimates (WASDE). Inclusion of multiple reports allows comparison of situation and outlook components of USDA information as well as comparison of impacts across all relevant reports. Daily futures returns from January 1985 through December 2004 are used in the analysis. The long sample period contains widely varying supply and demand conditions which should allow accurate estimation of information impacts.

In order to take into account the interaction of multiple reports available in hog and cattle markets, a time-series framework is selected. One of the challenges of this study is selection of an appropriate approach for modeling futures price changes. Such price movements are typically characterized by nonnormal, skewed distributions and nonlinear dynamics in variance and sometimes in the mean, thus making traditional OLS regressions unsuitable for the analysis. A TARCH-in-mean model of daily returns for hog and cattle futures prices is specified to allow for a time-varying risk premium and differential impacts of "good" and "bad" news on market volatility. The direct impact of USDA situation and outlook reports is estimated using a set of dummy variables in the variance equation. This model setup allows examination of individual impacts of government reports and their relative importance.

## USDA Reports

Cattle reports are published twice a year and contain the inventory numbers and values of all cattle and calves, number of operations, and size group estimates by class, state, and for the United States. Cattle on Feed (COF) reports are published monthly and concentrate on the inventory information for the U.S. livestock sector, such as the monthly total number of cattle and calves on feed, placements, marketings, and other disappearances; number of feedlots; and fed cattle marketings. Cold Storage (CS) reports are published monthly[1] and contain the regional and national end-of-month stocks of meats, dairy products, poultry products, fruits, nuts, and vegetables in public, private, and semi-private refrigerated warehouses. Hogs and Pigs reports (HPR) historically were issued four times a year. However, the schedule changed to monthly releases from January 2001 through September 2003, after which they returned to a quarterly schedule. These reports present data on the U.S. pig crop for major states and the United States, including inventory number by class, weight group, and value of hogs and pigs, farrowings, and farrowing intentions. The Livestock, Dairy, and Poultry Outlook (LDPO) report was issued four times a year from 1985 to 1991, five times in 1992, six times in 1993, and became monthly in 1994 (with the exception of 1998, when only seven reports were issued). This report provides mainly outlook information for the U.S. livestock, dairy, and poultry sectors focusing on current production, consumption, trade, prices received, and other issues. World Agricultural Supply and Demand Estimates (WASDE) reports are issued monthly and provide a marketing year balance sheet of supply, consumption, stocks, and prices for major commodities.

In aggregate, 1,027 reports were released during the 5,046 business days from January 2, 1985 through December 30, 2004. The monthly reports (Cattle on Feed, WASDE, and Cold Storage) were published 240, 240, and 239 times, respectively, during the study period, while the other reports were released less often: LDPO 166 times; Hogs and Pigs 102 times; and Cattle 40 times. The release dates are known and somewhat lumpy—i.e., 1,027 reports were released on 883 days. Cattle, Cattle on Feed, and Cold Storage reports were released in clusters about 50% of the time. Other reports were not substantially affected by clustering. Typically, these reports were released at 3:00 pm EST after the end of the daily trading session at the Chicago Mercantile Exchange, with the only exception being the WASDE report, whose release schedule changed from the afternoon following the close of trading to the morning before the start of trading in May 1994.

The release of the six major reports in the hog and cattle markets described above represent "events" for the purposes of this study. Because we are interested in the market reaction to these reports, the trading sessions immediately following report releases are considered event days.

---

[1] The only exception was in 1997, when no report was issued in January.

## Hog and Cattle Futures Returns

Hog and cattle market reaction to the USDA reports is measured here in terms of futures price changes (returns). Returns are calculated as log (continuously compounded) percentage changes in the nearby futures contract prices for hogs and cattle during the period from January 2, 1985 through December 30, 2004. Nearest-to-maturity (nearby) contracts are the most heavily traded, and hence liquid contracts. The specific futures maturity matched to each report release month is presented in table 1. The hog series uses live hog futures prices through November 1996, and lean hog futures prices from December 1996 onward. The February 1997 contract was the first lean hog futures contract to be traded at the Chicago Mercantile Exchange (CME).

In constructing the time series, rollovers between contracts occur on the last trading day of the month before the contract maturity month. The daily price changes are calculated in percentage terms as follows:

$$R_{t,i} = \ln\left(p_{t,i} / p_{t-1,i}\right) * 100, \quad (1)$$

where $p_{t,i}$ is the price of the nearest-to-maturity futures contract for time $t$ and commodity $i$, $p_{t-1,i}$ is the price of the nearest-to-maturity futures contract for time $t - 1$ and commodity $i$, and ln is the natural logarithm function. Returns are calculated on a close-to-open (overnight) basis, where the time index in equation (1) refers to the event day trading session ($t$) and the previous day ($t - 1$). The use of close-to-open changes is motivated by the fact that most reports are released after the close of trading on the release date and some before the opening of trading on the release date (WASDE reports from May 1994 and after). Efficient market theory suggests the impact of USDA reports, if any, should be reflected instantaneously in futures prices as soon as a trading session begins. This theory implies close-to-open price changes spanning the release time of USDA reports will best reflect the immediate reaction of hog and cattle futures prices to the new information disclosed in the reports. Price reaction measured on a close-to-close basis, as in previous studies, may mask the market's reaction to USDA reports due to the added variability associated with other information that becomes available to the market during the trading day.[2] Open-to-close (daytime) and close-to-close returns are used to test sensitivity of the results to overnight returns.

---

[2] This point can be illustrated with a simple example. First, decompose the variance of close-to-close price changes as follows: var($cc$) = var($co$) + var($oc$) + 2 cov($co$, $oc$), where var($cc$) is the variance of close-to-close price changes, var($co$) is the variance of close-to-open price changes, var($oc$) is the variance of open-to-close price changes, and cov($co$, $oc$) is the covariance of close-to-open and open-to-close price changes. Under market efficiency, the covariance of sequential close-to-open and open-to-close price changes is zero, and the decomposition can be simplified to: var($cc$) = var($co$) + var($oc$). Now, define the variances on normal days versus report days as follows:

| | var($cc$) | = | var($co$) | + | var($oc$) |
|---|---|---|---|---|---|
| Normal Days | 1.50 | = | 0.50 | + | 1.00 |
| Report Days | 1.75 | = | 0.75 | + | 1.00 |

Consistent with actual price behavior in agricultural futures markets, the variance of open-to-close price changes ("daytime variance") in this example is twice that of close-to-open price changes ("overnight variance"). Notice that the variance of close-to-open price changes on report days increases from 0.50 to 0.75, a 50% increase, due to the release of new information before the open. The variance of open-to-close price changes is assumed not to change, reflecting the instantaneous reaction of prices on the open. Consequently, the variance of close-to-close price changes increases only from 1.50 to 1.75, a 16.7% increase. Thus, the measurement of the market's reaction to the release of reports is substantially reduced when measured on a close-to-close basis due to the dominant effect of open-to-close price variability on close-to-close variability. From a statistical standpoint, the power of test statistics will be substantially higher when detecting variance increases on the order of 50% compared to 16.7%.

**Table 1. Chicago Mercantile Exchange (CME) Futures Contracts Used in Market Reaction Tests**

| Month of Report Release | Live/Lean Hog Futures Contract | Live Cattle Futures Contract |
|---|---|---|
| January | February | February |
| February | April | April |
| March | April | April |
| April | June | June |
| May | June | June |
| June | July | August |
| July | August | August |
| August | October | October |
| September | October | October |
| October | December | December |
| November | December | December |
| December | February | February |

Measuring market reaction in hog and cattle futures price series is complicated by the presence of limit moves. Limit moves in the futures price series restrict futures price movements, and thus futures prices may not adequately represent market prices on the days with limit moves. Therefore, the use of futures prices which are affected by limit moves may cause biased estimates of price volatility.

Historically, price changes of live hog contracts were limited at $1.50 per contract and changes of lean hog futures prices at $2 per contract. During the period of study live/lean hog futures prices were subject to limit moves a total of 36 times on a close-to-open basis. Changes in live cattle futures prices were limited at $1.50 per contract until December 26, 2003, when a system of "expandable" price limits was adopted by CME in response to the U.S. bovine spongiform encephalopathy (BSE, or "mad cow") disease crisis. Under this expandable limit system, the limits for February 2005 live cattle futures were increased to $3 per contract on December 26, and $5 per contract on December 29 and 30, 2004. The CME replaced these expandable limits with a fixed $3 per contract daily limit, effective Monday, February 23, 2004. Over the study period, live cattle futures returns reached the limit 28 times on a close-to-open basis. Thus the incidence of limit moves in the sample is small, 0.7% for live/lean hog futures and 0.6% for live cattle futures, suggesting the potential impact of limit moves in our empirical analysis should be negligible. Furthermore, McKenzie, Thomsen, and Dixon (2004) argue there is little concern that the existence of price limits leads to Type II errors in the analysis of hog and cattle futures returns. They demonstrate that abnormal returns are detected at levels well below 1%/day for large sample sizes, and for smaller samples at about 1.5%/day. These levels of abnormal returns are well within the range of price limits specified for the contracts over the study period. Therefore, price limits should not have a significant impact on the analysis conducted here.

Close-to-open percentage returns of daily live/lean hog and live cattle futures are plotted in figures 1 and 2, respectively. The returns of both commodities are characterized by consistent normal volatility which is interrupted by volatility spikes. The spikes in volatility are associated with arrival of important new pieces of information.

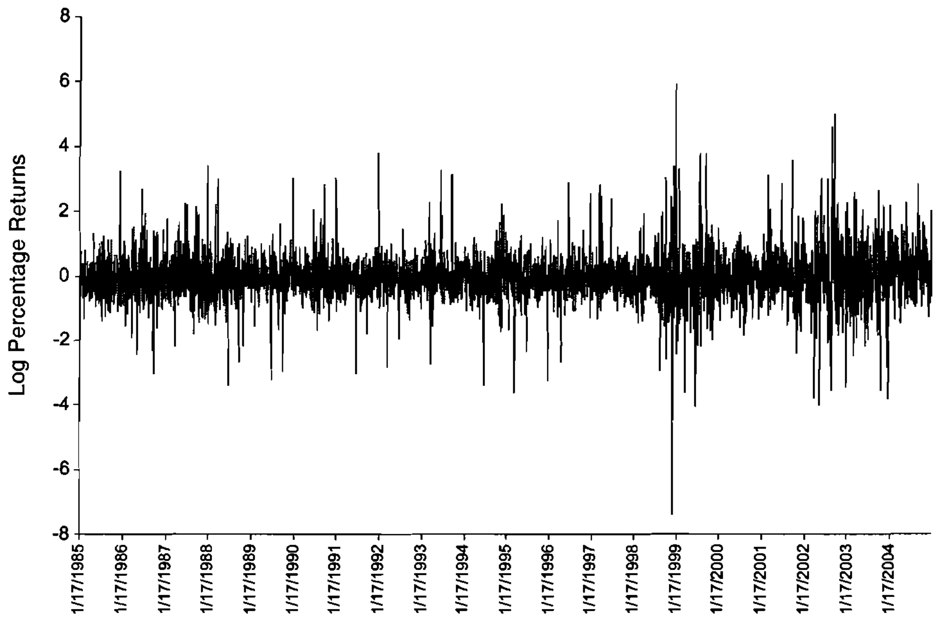


**Figure 1. Close-to-open live/lean hog futures returns, January 1985–December 2004**

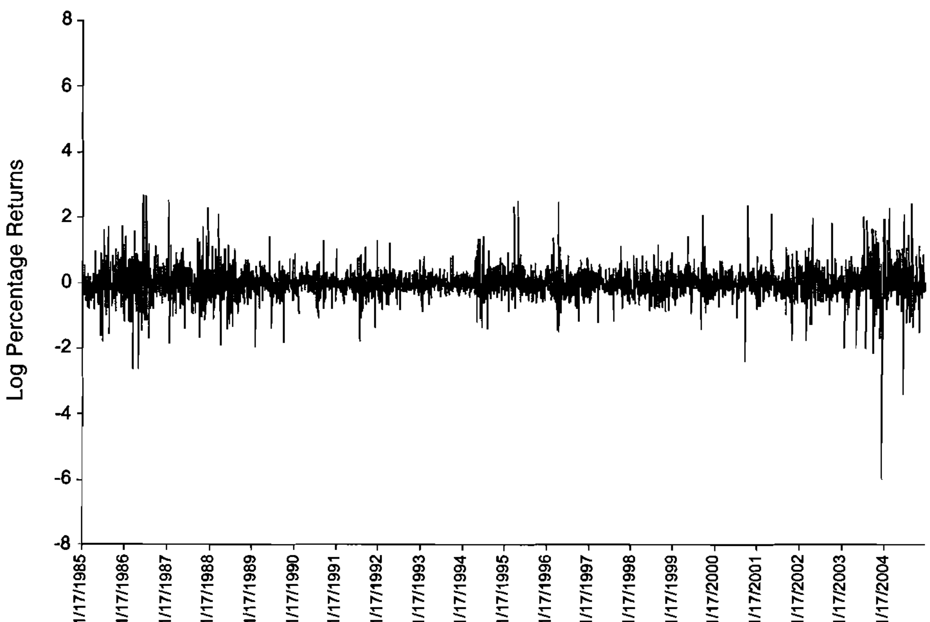


**Figure 2. Close-to-open live cattle futures returns, January 1985–December 2004**

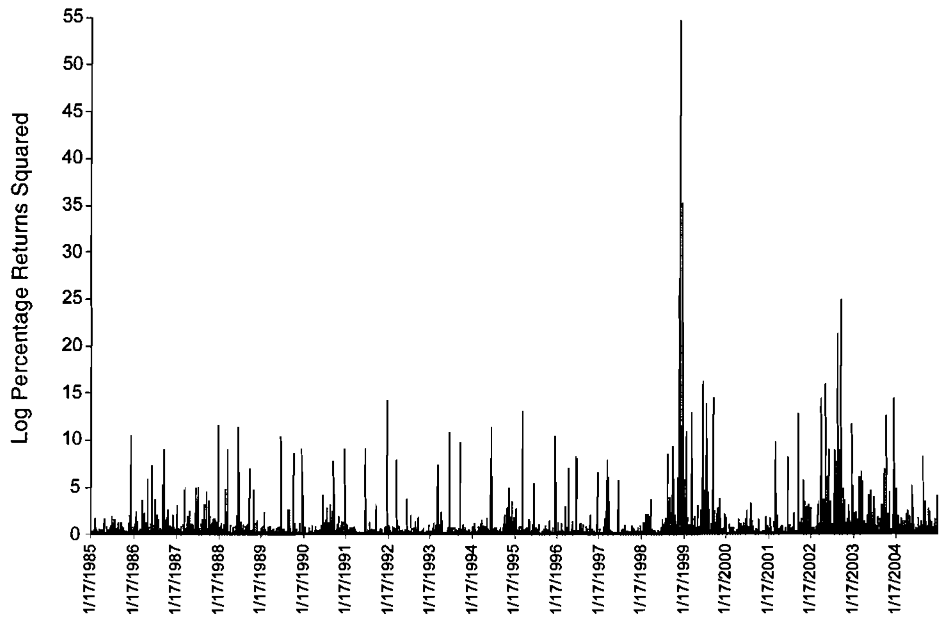


**Figure 3. Close-to-open live/lean hog futures squared returns, January 1985–December 2004**

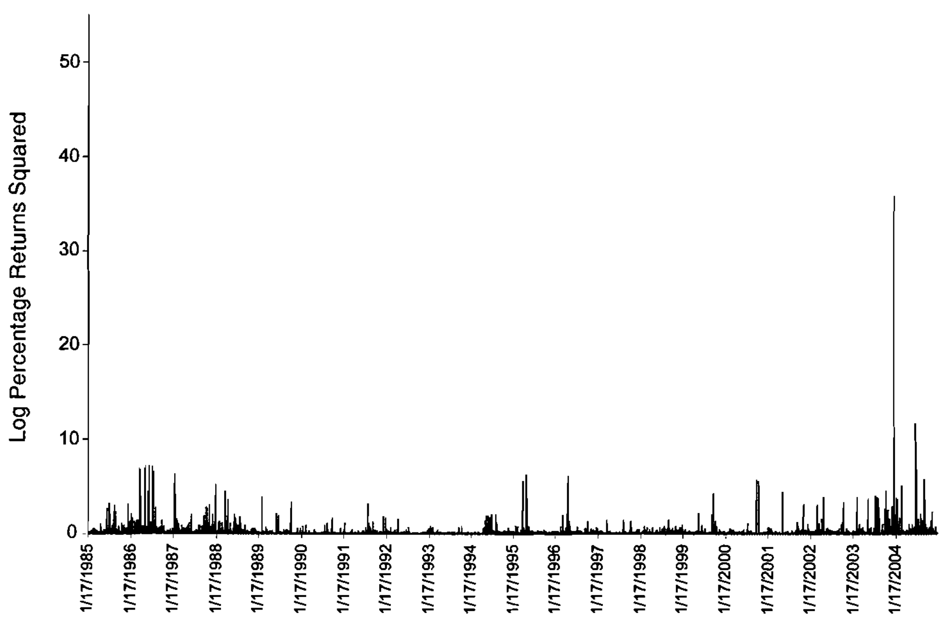


**Figure 4. Close-to-open live cattle futures squared returns, January 1985–December 2004**

**Table 2. Descriptive Statistics for Live/Lean Hog and Live Cattle Futures Returns, January 1985–December 2004**

| | | Live/Lean Hogs | | Live Cattle | |
|---|---|---|---|---|---|
| Sample/USDA Report | N | $\lvert \bar{R}_t \rvert$ | $\lvert \bar{R}_t^2 \rvert$ | $\lvert \bar{R}_t \rvert$ | $\lvert \bar{R}_t^2 \rvert$ |
| Full Sample | 5,046 | 0.479 | 0.515 | 0.273 | 0.187 |
| USDA Report: | | | | | |
| Cattle | 40 | 0.378 | 0.365 | 0.588 | 0.677 |
| Cattle on Feed (COF) | 240 | 0.521 | 0.512 | 0.528 | 0.521 |
| Cold Storage (CS) | 239 | 0.548 | 0.613 | 0.379 | 0.344 |
| Hogs and Pigs (HPR) | 102 | 1.524 | 3.968 | 0.524 | 0.685 |
| LDPO | 166 | 0.525 | 0.579 | 0.352 | 0.301 |
| WASDE | 240 | 0.454 | 0.442 | 0.265 | 0.169 |
| Report Days | 882 | 0.606 | 0.879 | 0.384 | 0.349 |
| Non-Report Days | 4,154 | 0.451 | 0.437 | 0.250 | 0.153 |

Note: $R_t$ is the close-to-open continuously compounded percentage return of live/lean hog or live cattle futures prices.

This study hypothesizes that at least some of this new information can be traced to USDA situation and outlook reports. Live/lean hog futures returns are in general much more volatile than live cattle returns. Volatility of live/lean hog and live cattle futures markets is plotted in figures 3 and 4 in terms of squared returns. The volatility of live/lean hog futures was somewhat higher from mid-1985 through mid-1988, from the end of 1988 through the end of 1999, and from the second part of 2002 through 2004. Live cattle futures were substantially less volatile than hog futures, with somewhat higher volatility observed from mid-1985 through mid-1988.

Descriptive statistics for close-to-open live/lean hog and live cattle futures returns are reported in table 2. Volatility is measured by both the absolute value of daily returns and the square of daily returns. These statistics support the findings of the graphical analysis by demonstrating that the mean absolute value of live/lean hog futures returns was almost two times greater than that of live cattle returns. As observed from table 2, the volatility of live/lean hog returns on report days, in terms of absolute returns, was 34% larger than on non-report days, and the volatility of live cattle returns was 54% larger. The biggest volatility increase for the live/lean hog market was associated with the Hogs and Pigs reports, followed by the Cold Storage, LDPO, Cattle on Feed, WASDE, and Cattle reports. Correspondingly, live cattle markets were most affected by the Cattle reports, followed by the Cattle on Feed, Hogs and Pigs, Cold Storage, LDPO, and WASDE reports. These data present evidence of greater unconditional volatility on report release days. The remainder of this paper seeks to provide insight on the differences in daily futures return volatility conditional on the various reports and other factors important in these markets.

## Futures Return Model

Futures return movements are typically characterized by nonnormal, skewed distributions and nonlinear dynamics in variance and sometimes in mean, thus making traditional OLS regressions unsuitable for their analysis (e.g., Yang and Brorsen, 1994). Previous studies demonstrate that GARCH-type models provide the most adequate representation of the distribution of daily futures returns (e.g., Akgiray, 1989; Yang and Brorsen, 1994). The basic form of a GARCH(1,1) process is written as:

$$(2)\qquad R_t = \varphi_0 + x_t'\varphi + \varepsilon_t, \quad \text{where } \varepsilon_t | \psi_{t-1} \sim N(0, h_t^2);$$
$$h_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta h_{t-1}^2,$$

where the mean equation consists of a constant ($\varphi_0$), a function of exogenous variables at time $t$ ($x_t'\varphi$), and an error term ($\varepsilon_t$); $h_t^2$ is the one-period-ahead forecast variance based on past information, termed conditional variance. The conditional variance ($h_t^2$) is written as a function of the constant ($\omega$), news measured as a square of yesterday's return ($\varepsilon_{t-1}^2$), and the previous forecast ($h_{t-1}^2$). If the constant of the variance equation ($\omega$) is expressed as a function of the long-run average variance rate ($V$), the equation can be rewritten as:

$$(3)\qquad h_t^2 = \vartheta V + \alpha\varepsilon_{t-1}^2 + \beta h_{t-1}^2.$$

This formulation demonstrates that the conditional variance of the GARCH process is calculated as a weighted average of the long-run average variance rate, the news measured as a square of yesterday's return, and the previous forecast. This model requires the weights to sum to one: $\vartheta + \alpha + \beta = 1$, implying $\vartheta$ can be calculated as $1 - \alpha - \beta$, and the long-run average variance ($V$) can then be calculated as $\omega/\vartheta$ (Hull, 2000, p. 373).

Autocorrelation observed in agricultural futures returns (e.g., Taylor, 1986; Yang and Brorsen, 1994) can be introduced in a basic GARCH model by including lagged values of returns in the mean equation. Previous studies have shown that autocorrelation may be present in at least 10 lags. The constant term ($\varphi_0$) of a GARCH model of futures returns is interpreted as the price of risk. A more realistic assumption is that the price of risk is not constant, but associated with the volatility of returns. The effects of volatility on the mean term can be modeled by including the conditional standard deviation into the mean equation. Additionally, in the recent financial literature it has been argued that markets react asymmetrically to "good" news and "bad" news. For example, Engle (2004) found negative returns had more than three times the effect of positive returns on future conditional variances of the S&P 500 index. This evidence is consistent with theories developed in the behavioral finance literature about how individuals react differently to good and bad news.[3] The asymmetry may be modeled using an asymmetric volatility model referred to as GJR-GARCH (Glosten, Jagannathan, and Runkle, 1993) or TARCH for Threshold ARCH (Zakoian, 1994). This model accounts for two types of news: a squared return when the news is positive ("good") and a squared return when the news is negative ("bad"):

$$(4)\qquad R_t = \varphi_0 + \sum_{s=1}^{10}\varphi_s R_{t-s} + \varphi_{s+1}h_t + \varepsilon_t, \quad \text{where } \varepsilon_t | \psi_{t-1} \sim N(0, h_t^2);$$
$$h_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \gamma\varepsilon_{t-1}^2 I_{\varepsilon_{t-1}<0} + \beta h_{t-1}^2,$$

[3] Clearly, the interpretation of "good" and "bad" news in the futures market would be different for short and long positions in the market. However, due to extensive evidence demonstrating the presence of asymmetric reaction to different types of news in equity markets, it was deemed important to allow for asymmetric reaction in this model.

where the exogenous variables of the mean equation include $s$ lags of returns ($R_t$) and conditional standard deviation ($h_t$); in the variance equation, $I = 1$ if $\varepsilon_{t-1} < 0$, and 0 otherwise. This formulation distributes the weights for the calculation of conditional variance into $1 - \alpha - \beta - \gamma/2$, $\beta$, $\alpha/2$, and $(\alpha + \gamma)/2$ for the unconditional variance, the previous forecast, the good news, and the bad news, respectively. The weights for $\alpha$ and $\alpha + \gamma$ are divided by two because these are the two components of total market response to the previous day's news (Engle, 2004, pp. 412–413).

While the outlined TARCH model captures the general path of "normal" return volatility, it does not account for shocks caused by external factors. The most common external effects include day-of-the-week effects (e.g., Junkus, 1986; Yang and Brorsen, 1994) and seasonality in variance (Anderson, 1985; Kenyon et al., 1987; Yang and Brorsen, 1994). The impact of external effects typically is introduced using dummy variables in the mean and/or variance equations. It is hypothesized that day of the week has an effect on both mean and variance, while seasonality has an effect on variance only.

Following numerous studies in the finance and macroeconomics literature (e.g., Engle and Ng, 1993; Jones and Lumsdaine, 1998; Bomfim, 2003), we assume that news announcements impact the volatility of market prices.[4] Thus, we introduce USDA report dummies in the variance equation and the full model is specified as:

$$(5) \qquad R_t = \varphi_0 + \sum_{s=1}^{10} \varphi_s R_{t-s} + \varphi_{11} h_t + \varphi_{12} D_M + \varphi_{13} D_T + \varphi_{14} D_W + \varphi_{15} D_H + \varepsilon_t;$$

$$\begin{aligned} h_t^2 = {} & \omega + \alpha \varepsilon_{t-1}^2 + \gamma \varepsilon_{t-1}^2 I_{\varepsilon_{t-1}<0} + \beta h_{t-1}^2 + \delta_1 D_M + \delta_2 D_T + \delta_3 D_W + \delta_4 D_H \\ & + \delta_5 D_{JAN} + \delta_6 D_{FEB} + \delta_7 D_{MAR} + \delta_8 D_{APR} + \delta_9 D_{MAY} + \delta_{10} D_{JUN} \\ & + \delta_{11} D_{JUL} + \delta_{12} D_{AUG} + \delta_{13} D_{SEP} + \delta_{14} D_{OCT} + \delta_{15} D_{NOV} + \delta_{16} D_{CATTLE} \\ & + \delta_{17} D_{COF} + \delta_{18} D_{CS} + \delta_{19} D_{HPR} + \delta_{20} D_{LDPO} + \delta_{21} D_{WASDE}, \end{aligned}$$

where the dummy variables for each day of the week are $D_M = 1$ if Monday and 0 otherwise, and so on (i.e., $D_T$, Tuesday; $D_W$, Wednesday; $D_H$, Thursday). Seasonality is introduced using dummies $D_{JAN}$ for January, $D_{FEB}$ for February, $D_{MAR}$ for March, $D_{APR}$ for April, $D_{MAY}$ for May, $D_{JUN}$ for June, $D_{JUL}$ for July, $D_{AUG}$ for August, $D_{SEP}$ for September, $D_{OCT}$ for October, and $D_{NOV}$ for November. The dummy variables for announcement days are $D_{CATTLE}$ for Cattle reports, $D_{COF}$ for Cattle on Feed reports, $D_{CS}$ for Cold Storage reports, $D_{HPR}$ for Hogs and Pigs reports, $D_{LDPO}$ for Livestock, Dairy, and Poultry Outlook reports, and $D_{WASDE}$ for WASDE reports.

Thus, the reference point for the mean equation is a Friday, and for the variance equation a Friday in December when no reports are released. The parameter estimates on the dummy variables indicate a change in the left-hand side variable due to the event indicated with a dummy relative to the reference point.[5] In other words, the parameters

[4] Some models of price movements specify price reactions as consisting of mean and variance components (e.g., Andersen et al., 2003). However, in order to correctly estimate mean price response, expectations data are required that differentiate "bullish" reports from "bearish" reports. Because such data are unavailable for all reports considered in this study, we concentrate on volatility reaction only.

[5] It should be pointed out that this specification restricts the impact of each type of USDA report (e.g., HPR) to be the same for all announcements. In other words, the coefficients on the report dummies measure the average impact across all announcements.

for dummy variables in the variance equation describe shocks in return volatility caused by respective external effects (intercept shifts). The remaining parameters of the variance equation provide information about the components of the "normal" level of volatility.

## Model Estimation Results

Model parameter estimates for each commodity were obtained using the E-Views econometric software package. TARCH estimates of the conditional variance of live/lean hog and live cattle futures returns (based on full models) are presented graphically in figures 5 and 6, respectively. These estimates may be compared with the daily squared returns presented in figures 3 and 4. As this graphical analysis suggests, our statistical models adequately represent movements in daily live/lean hog and live cattle futures returns.

Column sets [1] and [3] of table 3 present the results of modeling "normal" movements (i.e., no external effects) in live/lean hog and live cattle futures returns, respectively, over January 1985 through December 2004. The estimated coefficients indicate the price of risk for live/lean hog futures returns was a constant -0.137 plus a variable component of 0.203. These estimates imply that daily live/lean hog futures returns increase by 0.20 percentage points in response to each percentage point increase in conditional standard deviation of these returns. Similarly, the price of risk in cattle futures was a constant -0.014 plus a variable component of 0.044 [column set [3]). Autocorrelation was present in the first three, the fifth, and the ninth lags for live/lean hogs, and all 10 lags for live cattle.

As discussed in the modeling section, the weights for the calculation of conditional variance components are $1 - \alpha - \beta - \gamma/2$, $\beta$, $\alpha/2$, and $(\alpha + \gamma)/2$ for the unconditional variance, the previous forecast, the good news, and the bad news, respectively. The long-run unconditional variance can be calculated as $\omega/(1 - \alpha/2 - \gamma/2 - \beta)$. The variance estimates suggest that the conditional variance of live/lean hog futures places a weight of about 4.2% on the long-run unconditional variance (equal to 0.33/day), a weight of about 89% on the prior day's conditional variance estimate, a weight of 2.1% on the prior day's good news about volatility, and a weight of 4.8% on the prior day's bad news about volatility. The conditional variance estimate of live cattle futures returns places a weight of about 1% on the long-run unconditional variance (equal to 0.06/day), a weight of about 93% on the prior day's conditional variance estimate, a weight of 2.3% on the prior day's good news about volatility, and a weight of 3.7% on the prior day's bad news about volatility. These estimates are consistent with previous findings in financial markets which show a stronger reaction to negative news than to positive news (e.g., Engle, 2004).

The results also suggest one caveat for our statistical approach. Because of the heavy reliance on the previous volatility estimate, TARCH estimates of conditional volatility exhibit persistence following large shocks. This effect has been observed and discussed in some previous studies using autoregressive models (e.g., Andersen and Bollerslev, 1998; Li and Engle, 1998). It implies that the estimated volatility shocks do not disappear on the following day, but tend to decay over several days. This pattern may not always be consistent with actual movements of these return series and may have caused us to overestimate the "normal" volatility of returns and underestimate the statistical significance of "shock" coefficients.

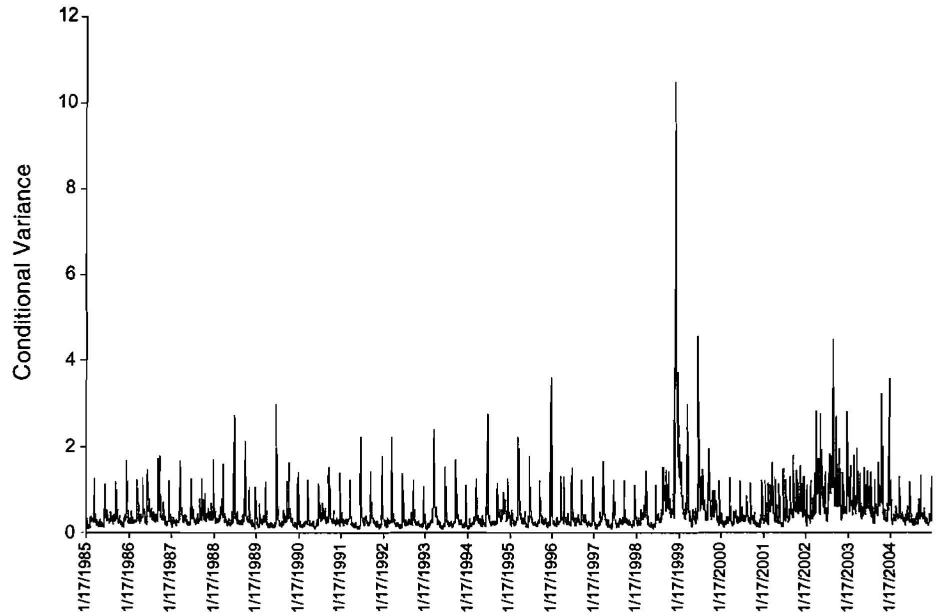


**Figure 5. Estimated conditional variance of close-to-open live/ lean hog futures returns, January 1985–December 2004**

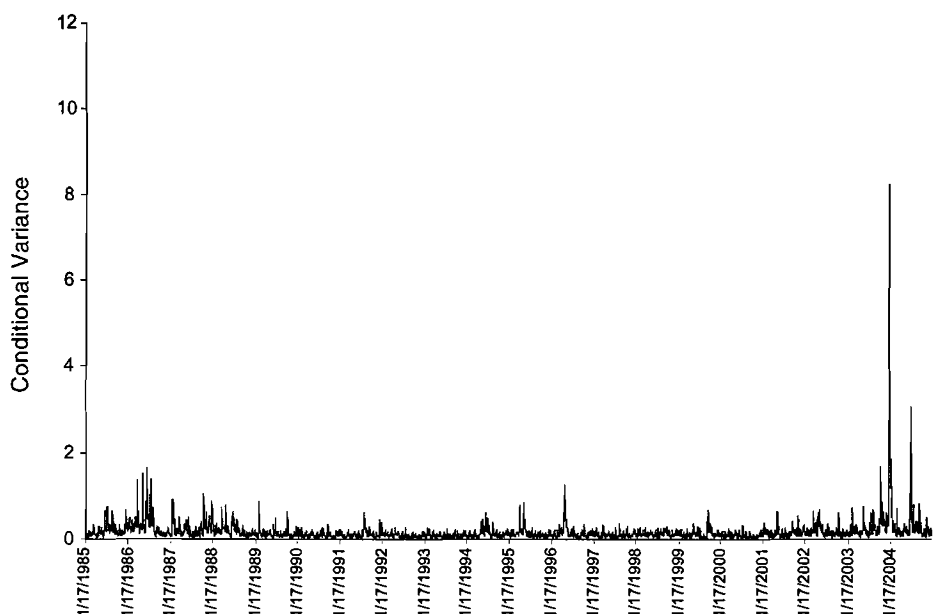


**Figure 6. Estimated conditional variance of close-to-open live cattle futures returns, January 1985–December 2004**

**Table 3. TARCH Model Estimation Results for Live/Lean Hog and Live Cattle Close-to-Open Futures Returns, January 1985–December 2004 ($N$ = 5,036)**

| | Live/Lean Hogs | | | | Live Cattle | | | |
|---|---|---|---|---|---|---|---|---|
| | [1] No External Effects | | [2] Full System | | [3] No External Effects | | [4] Full System | |
| Parameter | Coefficient | Prob. | Coefficient | Prob. | Coefficient | Prob. | Coefficient | Prob. |
| **Mean Equation:** | | | | | | | | |
| Constant | -0.137 | 0.001 | -0.032 | 0.315 | -0.014 | 0.016 | -0.023 | 0.227 |
| $y_{t-1}$ | 0.165 | 0.000 | 0.156 | 0.000 | 0.141 | 0.014 | 0.155 | 0.000 |
| $y_{t-2}$ | -0.043 | 0.008 | -0.031 | 0.052 | 0.098 | 0.015 | 0.088 | 0.000 |
| $y_{t-3}$ | 0.030 | 0.049 | 0.032 | 0.038 | 0.040 | 0.016 | 0.035 | 0.037 |
| $y_{t-4}$ | 0.009 | 0.578 | 0.024 | 0.107 | 0.039 | 0.015 | 0.039 | 0.009 |
| $y_{t-5}$ | 0.035 | 0.020 | 0.025 | 0.081 | 0.005 | 0.015 | 0.005 | 0.727 |
| $y_{t-6}$ | 0.006 | 0.669 | 0.014 | 0.303 | -0.008 | 0.016 | -0.015 | 0.277 |
| $y_{t-7}$ | 0.018 | 0.212 | 0.007 | 0.612 | 0.003 | 0.014 | -0.004 | 0.775 |
| $y_{t-8}$ | 0.018 | 0.219 | 0.021 | 0.112 | 0.004 | 0.015 | -0.001 | 0.945 |
| $y_{t-9}$ | 0.031 | 0.036 | 0.036 | 0.005 | 0.021 | 0.015 | 0.011 | 0.419 |
| $y_{t-10}$ | 0.015 | 0.294 | 0.009 | 0.462 | 0.001 | 0.013 | 0.002 | 0.845 |
| $h_t$ | 0.203 | 0.002 | 0.122 | 0.013 | 0.044 | 0.049 | 0.054 | 0.182 |
| $D_M$ (Monday) | | | -0.062 | 0.016 | | | -0.009 | 0.588 |
| $D_T$ (Tuesday) | | | -0.072 | 0.005 | | | 0.020 | 0.212 |
| $D_W$ (Wednesday) | | | -0.109 | 0.000 | | | 0.015 | 0.345 |
| $D_H$ (Thursday) | | | -0.015 | 0.554 | | | 0.000 | 0.982 |
| **Variance Equation:** | | | | | | | | |
| Constant | 0.021 | 0.000 | 0.017 | 0.160 | 0.002 | 0.000 | 0.035 | 0.000 |
| $\varepsilon_{t-1}^2$ | 0.042 | 0.000 | 0.064 | 0.000 | 0.046 | 0.000 | 0.124 | 0.000 |
| $\varepsilon_{t-1}^2 I_{\varepsilon_{t-1},0}$ | 0.054 | 0.000 | 0.084 | 0.000 | 0.028 | 0.000 | 0.047 | 0.001 |
| $h_{t-1}^2$ | 0.889 | 0.000 | 0.803 | 0.000 | 0.930 | 0.000 | 0.772 | 0.000 |
| $D_M$ (Monday) | | | 0.022 | 0.253 | | | -0.026 | 0.001 |
| $D_T$ (Tuesday) | | | -0.032 | 0.087 | | | -0.048 | 0.000 |
| $D_W$ (Wednesday) | | | 0.004 | 0.809 | | | -0.009 | 0.105 |
| $D_H$ (Thursday) | | | 0.016 | 0.440 | | | -0.034 | 0.000 |
| $D_{JAN}$ (January) | | | -0.012 | 0.016 | | | -0.004 | 0.053 |
| $D_{FEB}$ (February) | | | 0.001 | 0.877 | | | -0.009 | 0.000 |
| $D_{MAR}$ (March) | | | 0.015 | 0.001 | | | -0.002 | 0.444 |
| $D_{APR}$ (April) | | | -0.003 | 0.557 | | | -0.007 | 0.001 |
| $D_{MAY}$ (May) | | | 0.000 | 0.928 | | | 0.009 | 0.000 |
| $D_{JUN}$ (June) | | | -0.003 | 0.525 | | | -0.009 | 0.000 |
| $D_{JUL}$ (July) | | | -0.004 | 0.462 | | | -0.010 | 0.000 |
| $D_{AUG}$ (August) | | | 0.004 | 0.410 | | | -0.005 | 0.006 |
| $D_{SEP}$ (September) | | | 0.007 | 0.147 | | | -0.007 | 0.000 |
| $D_{OCT}$ (October) | | | 0.009 | 0.120 | | | -0.005 | 0.020 |
| $D_{NOV}$ (November) | | | 0.001 | 0.848 | | | -0.008 | 0.000 |

( continued . . . )

**Table 3. Continued**

| | Live/Lean Hogs | | | | Live Cattle | | | |
|---|---|---|---|---|---|---|---|---|
| | [1] No External Effects | | [2] Full System | | [3] No External Effects | | [4] Full System | |
| Parameter | Coefficient | Prob. | Coefficient | Prob. | Coefficient | Prob. | Coefficient | Prob. |
| **Variance Equation (cont'd.):** | | | | | | | | |
| $D_{CATTLE}$ (Cattle) | | | 0.016 | 0.661 | | | 0.134 | 0.000 |
| $D_{COF}$ (Cattle on Feed) | | | 0.038 | 0.050 | | | 0.093 | 0.000 |
| $D_{CS}$ (Cold Storage | | | 0.007 | 0.729 | | | -0.008 | 0.127 |
| $D_{HPR}$ (Hogs and Pigs) | | | 0.938 | 0.000 | | | 0.134 | 0.000 |
| $D_{LDPO}$ (LDPO) | | | 0.056 | 0.002 | | | -0.019 | 0.000 |
| $D_{WASDE}$ (WASDE) | | | 0.030 | 0.084 | | | 0.024 | 0.000 |
| **Diagnostics:** | | | | | | | | |
| $R^2$ | 0.037 | | 0.041 | | 0.053 | | 0.055 | |
| Adjusted $R^2$ | 0.034 | | 0.033 | | 0.050 | | 0.047 | |
| S.E. of Regression | 0.705 | | 0.705 | | 0.419 | | 0.420 | |
| $F$-Statistic | 12.779 | | 5.327 | | 18.850 | | 7.199 | |
| Prob($F$-Statistic) | 0.000 | | 0.000 | | 0.000 | | 0.000 | |
| Log Likelihood | -4,986.630 | | -4,661.217 | | -2,036.798 | | -1,943.212 | |
| Likelihood-Ratio Test | | | 325.566 | | | | 37.576 | |
| Prob(LR Test) | | | 0.000 | | | | 0.000 | |

Notes: The dependent variable is the close-to-open continuously compounded percentage return of live/lean hog or live cattle futures prices. Likelihood-ratio (LR) tests reflect the joint impact of USDA reports. The original sample size of 5,046 is reduced by 10 observations used to calculate lagged returns.

The second part of the empirical analysis in this study was devoted to an investigation of the impact of external factors on daily volatility of live/lean hogs and live cattle futures. Because the external effects were introduced through a series of dummy variables, the estimates should be interpreted relative to the base alternative of a Friday in December. The results presented in column sets [2] and [4] of table 3 suggest that day-of-the-week effects were present in live/lean hog futures returns mostly in the mean, and in live cattle returns in the variance. All Monday, Tuesday, and Wednesday returns appeared to be lower than Friday returns by 0.06 to 0.11 percentage points in the live/lean hog futures market. Live/lean hog futures were also slightly less volatile on Tuesdays. Cattle futures returns tended to be 0.07 percentage points greater on Tuesdays, and more volatile on Mondays and Wednesdays and less volatile on Tuesdays relative to Fridays. Seasonality effects were present mostly in live cattle futures returns. Cattle futures were significantly less volatile than December returns in every month except May, when they were more volatile. Live/lean hog futures returns were less volatile in January and more volatile in March relative to December. While these seasonality effects are statistically significant, the magnitudes are quite small.

## Impact of USDA Reports

According to the "full system" results presented in table 3 (column sets [2] and [4]), positive signs for USDA report impacts are estimated in all but two cases: Cold Storage and LDPO reports in live cattle. Positive signs indicate USDA reports increase the conditional variance of returns on days following report releases, and under market efficiency, provide new information to market participants. Negative signs are anomalous, as they indicate a USDA report is associated with decreases in conditional variance and reducing the amount of information available to the market. With the exception of Cattle and Cold Storage reports, all reports had a significant impact on live/lean hog returns, and all but Cold Storage reports had a significant impact on live cattle returns (at the 10% significance level). The overall impact of USDA reports is reflected in the values of the likelihood-ratio test, which were significant at the 1% level. In general, the estimation results clearly reveal that USDA reports were an important source of new information in daily hog and cattle futures returns.

From a magnitude perspective, release of USDA reports increased conditional variance of live/lean hog futures by a factor as large as 0.938, and conditional variance of live cattle futures by a factor as large as 0.134. While the size of these effects may appear small in absolute value, they should be interpreted relative to average variance of the daily futures return series. Additionally, since return volatility in agricultural markets is often perceived in terms of standard deviation, these results can be translated to changes in standard deviation of the underlying futures returns using the following comparative statics result:

$$\frac{\partial h_t}{\partial D_i} = \frac{\partial h_t}{\partial h_t^2} \times \frac{\partial h_t^2}{\partial D_i} = \frac{1}{2h_t} \times \delta_i = \frac{\delta_i}{2h_t}. \tag{6}$$

This formula is evaluated using the $\delta_i$ parameter estimates and the mean conditional standard deviation estimates from the TARCH equation for each commodity.

According to the results presented at the top of table 4, the average conditional standard deviation of live/lean hog returns was 0.699%/day, and of live cattle returns 0.423%/day.[6] The other variables presented in table 4 should be interpreted carefully. To begin, the partial derivative $(\partial \hat{h}_t / \partial D_i)$ should be interpreted as the increase in conditional standard deviation associated with a given external event. For example, the partial derivative for Cattle reports in live/lean hogs, 0.011, indicates that the conditional standard deviation of live/lean hog futures increased by 0.011 percentage points on days following Cattle report releases. The percentage columns (proportion of mean $\hat{h}_t$) in table 4 likely provide the most meaningful results from an economic perspective. The percentage represents the increase in conditional standard deviation associated with external events expressed as a proportion of the mean conditional standard deviation. This allows a more direct comparison of the magnitude of market impacts of the different external factors. For example, results show that the conditional standard deviation of live/lean hog futures was 1.6% (0.011/0.699 × 100) greater on days following the release of Cattle reports. Similarly, the conditional standard deviation of live cattle futures returns was 37.5% (0.159/0.423 × 100) greater on days following the release of Cattle reports.

Based on the results presented in table 4, Hogs and Pigs reports had the largest impact in the live/lean hog market, and Cattle, Cattle on Feed, and Hogs and Pigs reports

[6] These results may be interpreted in absolute terms based on the average daily futures price of lean hogs during the study period of about \$62/cwt (the price of live hogs was divided by a factor of 0.74 for the calculation of the average price of lean hogs) and the average price of live cattle at \$70/cwt. Specifically, in dollar terms the conditional standard deviation of the close-to-open futures returns was \$0.43/cwt for lean hogs and \$0.30/cwt for live cattle.

**Table 4. Impact of External Factors on Conditional Standard Deviation of Live/Lean Hog and Live Cattle Futures Returns, January 1985–December 2004 ($N$ = 5,036)**

| Description | Live/Lean Hogs [Mean Conditional Standard Deviation ($\hat{h}_t$) = 0.699%/day] | | Live Cattle [Mean Conditional Standard Deviation ($\hat{h}_t$) = 0.423%/day] | |
|---|---|---|---|---|
| | $\partial\hat{h}_t/\partial D_i$ | Proportion of Mean $\hat{h}_t$ | $\partial\hat{h}_t/\partial D_i$ | Proportion of Mean $\hat{h}_t$ |
| $D_M$ (Monday) | -0.045 | -6.4% | -0.011 | -2.6% |
| $D_T$ (Tuesday) | -0.051 | -7.3% | 0.024 | 5.6% |
| $D_W$ (Wednesday) | -0.078 | -11.2% | 0.018 | 4.2% |
| $D_H$ (Thursday) | -0.011 | -1.5% | 0.000 | 0.1% |
| $D_{JAN}$ (January) | -0.009 | -1.2% | -0.005 | -1.2% |
| $D_{FEB}$ (February) | 0.001 | 0.1% | -0.011 | -2.6% |
| $D_{MAR}$ (March) | 0.011 | 1.6% | -0.002 | -0.5% |
| $D_{APR}$ (April) | -0.002 | -0.3% | -0.008 | -2.0% |
| $D_{MAY}$ (May) | 0.000 | 0.0% | 0.010 | 2.5% |
| $D_{JUN}$ (June) | -0.002 | -0.3% | -0.010 | -2.4% |
| $D_{JUL}$ (July) | -0.003 | -0.4% | -0.012 | -2.8% |
| $D_{AUG}$ (August) | 0.003 | 0.5% | -0.006 | -1.5% |
| $D_{SEP}$ (September) | 0.005 | 0.8% | -0.009 | -2.1% |
| $D_{OCT}$ (October) | 0.006 | 0.9% | -0.006 | -1.3% |
| $D_{NOV}$ (November) | 0.001 | 0.1% | -0.009 | -2.2% |
| $D_{CATTLE}$ (Cattle) | 0.011 | 1.6% | 0.159 | 37.5% |
| $D_{COF}$ (Cattle on Feed) | 0.027 | 3.9% | 0.110 | 26.0% |
| $D_{CS}$ (Cold Storage) | 0.005 | 0.7% | -0.010 | -2.3% |
| $D_{HPR}$ (Hogs and Pigs) | 0.671 | 96.0% | 0.158 | 37.5% |
| $D_{LDPO}$ (LDPO) | 0.040 | 5.8% | -0.023 | -5.4% |
| $D_{WASDE}$ (WASDE) | 0.022 | 3.1% | 0.029 | 6.8% |

Note: The dependent variable is the close-to-open continuously compounded percentage return of live/lean hog or live cattle futures prices.

had the largest impact in the live cattle market. The conditional standard deviation of live/lean hog futures was 96% greater on the days following the release of Hogs and Pigs reports.[7] Similarly, the conditional standard deviation of live cattle futures returns was 37.5% greater on the days following Cattle reports as well as Hogs and Pigs reports, and 26% greater on the days following Cattle on Feed reports.[8] The impact of the other reports may be interpreted in similar manner. While Hogs and Pigs reports dominated hog market impacts, cattle markets were substantially affected by three reports: Cattle, Hogs and Pigs, and Cattle on Feed. Cold Storage reports had the smallest impact (0.7%) in the live/lean hog market, and LDPO reports (-5.4%) and Cold Storage reports (-2.3%) ranked lowest in the live cattle market.

[7] In absolute terms, a 96% increase in a conditional standard deviation of close-to-open lean hog futures is about $0.69/cwt (based on $62/cwt average price).

[8] In absolute terms, a 37.5% increase in a conditional standard deviation of close-to-open live cattle futures is about $0.16/cwt, and a 26% increase is about $0.11/cwt (based on $70/cwt average price).

The relative importance of USDA reports is revealed by comparison of the impacts of USDA reports to the impacts of the other external factors considered in this study. The results presented in table 4 indicate that the conditional standard deviation of live/lean hog close-to-open returns varied by 1.5% to 11.2% due to day-of-the-week effects, and by 0.1% to 1.6% due to seasonality effects. Similarly, the conditional standard deviation of live cattle close-to-open returns varied by 0.1% to 5.6% due to day-of-the-week effects, and by 0.5% to 2.8% due to seasonality effects. These results suggest that the impact of Hogs and Pigs reports on live/lean hog prices and the impact of Cattle, Cattle on Feed, and Hogs and Pigs reports on cattle prices was stronger than both seasonality and day-of-the-week effects. The impact of Cold Storage reports was comparable to the impact of seasonality effects. The impacts of other reports considered in this study were comparable to the day-of-the-week effects.

The results also allow comparison of the relative importance of situation and outlook information released by the USDA. LDPO and WASDE reports may be considered outlook reports because they primarily contain the results of economic analysis, while the four other reports are best described as situation or inventory reports. Based on the results reported in table 4, the impact of Hogs and Pigs reports on the average conditional standard deviation of live/lean hog returns was 16.6 times greater than the impact of LDPO reports, and 31 times greater than the impact of WASDE reports. Similarly, the impact of Cattle reports on live cattle prices was 5.5 times greater than the impact of WASDE reports. Overall, these findings suggest a much larger impact in livestock markets by situation information compared to outlook information.

## Sensitivity Analysis

To this point in the paper, the analysis assumes that markets are efficient and they react to new information instantaneously. Therefore, the use of close-to-open price changes should better reflect the impact of USDA reports than the use of close-to-close price changes, which may mask the market's reaction to reports due to the added variability associated with other information that becomes available to the market during the trading day (see footnote 2). However, the use of close-to-open returns to detect USDA report impacts could be misleading if the reaction of hog and cattle futures markets at the opening of trading sessions is inefficient, i.e., under- or over-reaction. In these cases, close-to-close price changes would offer a better measure of information impact on equilibrium prices. This section provides a sensitivity analysis of the results to the assumption of efficient market reaction to information.

In reality, markets may react to new information in several different ways. First, as discussed above, price may instantaneously reach a new equilibrium under market efficiency which fully reflects the impact of new information. When information arrives between daily trading sessions, as is the case with the USDA reports, this reaction is reflected in increased volatility of futures prices at the open of trading sessions, followed by no reaction to the information during the rest of the trading sessions. Therefore, close-to-open returns reflect the full impact of the new information, the following open-to-close returns reflect no impact, and close-to-close returns reflect the impact dampened by additional information arriving during the day.

Second, if the market is not efficient and tends to over-react to new information, the initial reaction is too extreme and price subsequently reverses direction to arrive at the true equilibrium level at some later point during a trading session. This reaction is reflected in increased volatility of futures prices at the opening of trading sessions, a continued increase in volatility during trading sessions, but a small or no change in volatility measured at the close of trading sessions (because the previous two reactions tend to cancel out). In this case, close-to-open returns reflect an inflated impact, open-to-close returns reflect the reverse, and close-to-close returns reflect the true equilibrium (assuming reaction is complete by the end of trading sessions).

Third, markets may react to new information slowly, with the initial price reaction not reflecting the full impact of the new information. Prices continue adjusting in the same direction throughout the trading session.[9] This reaction is reflected in increased volatility of futures prices at the open, a continued increase in volatility during the trading session, and an increase in volatility at the close which is equal to or greater than the sum of overnight and daytime reactions. Thus, close-to-open returns reflect incomplete reaction, open-to-close returns reflect continued reaction, and close-to-close returns reflect the full reaction (again assuming reaction is complete by the end of the trading session).

Table 5 compares the results of TARCH model estimation using close-to-open, open-to-close and close-to-close returns. These results demonstrate that hog and cattle futures markets appear to react efficiently to news in most cases, including Cattle on Feed, LDPO, and WASDE reports in hog markets, and reaction to Cattle,[10] LDPO, and WASDE reports in cattle markets (significant impact using close-to-open returns and negligible impact using open-to-close and close-to-close returns). Exceptions to efficiency are also present. For example, hog market reaction to Hogs and Pigs reports reveals an over-reaction pattern (significant impact using close-to-open and open-to-close returns but a smaller reaction using close-to-close returns). Cattle market reaction to Cattle on Feed reports and Hogs and Pigs reports indicates an under-reaction pattern (significant impact using all three return measures, with the largest reaction associated with close-to-close returns). Hog market reaction to Cattle reports, although not statistically significant, is also consistent with under-reaction.

In sum, as predicted by market efficiency theory, measuring market impact using close-to-open returns is the most accurate approach in a majority of cases. However, market impact is over-estimated using close-to-open returns for Hogs and Pigs reports in the hog market, and under-estimated for Cattle on Feed and Hogs and Pigs reports in the cattle market. Nonetheless, the exceptions do not alter our earlier conclusion that USDA reports are a powerful source of shocks to the normal movement of daily hog and cattle futures returns, and thereby provide important new information to market participants. The sensitivity analysis does suggest that a complete understanding of the dynamics of market reaction to USDA reports requires the use of all three measures of returns.

---

[9] Some previous studies document this type of reaction to unexpected news announcements (e.g., Rucker, Thurman, and Yoder, 2005).

[10] The fact that a strong cattle market reaction to Cattle reports at the open virtually disappears by the close may reflect the use of nearby futures contracts to detect report impact. Specifically, inventory information reported in Cattle reports may have a larger and more consistent impact on deferred futures prices due to the longer production cycle in cattle. This study uses nearby futures in order to consistently measure market reaction for all reports. The impact of USDA reports on deferred futures prices represents an interesting topic for further research.

**Table 5. Sensitivity Analysis of TARCH Model Estimation Results for Live/Lean Hog and Live Cattle Futures Returns, January 1985–December 2004 ($N$ = 5,036)**

| | Futures Return Definition | | | | | |
|---|---|---|---|---|---|---|
| | Close-to-Open | | Open-to-Close | | Close-to-Close | |
| Report | Coefficient ($\hat{\delta}_i$) | Prob. | Coefficient ($\hat{\delta}_i$) | Prob. | Coefficient ($\hat{\delta}_i$) | Prob. |
| **A. Live/Lean Hogs:** | | | | | | |
| Cattle | 0.016 | 0.661 | 0.112 | 0.562 | 0.317 | 0.218 |
| Cattle on Feed | 0.038 | 0.050 | -0.135 | 0.114 | -0.071 | 0.534 |
| Cold Storage | 0.007 | 0.729 | -0.005 | 0.959 | 0.039 | 0.745 |
| Hogs and Pigs | 0.938 | 0.000 | 0.195 | 0.025 | 0.743 | 0.000 |
| LDPO | 0.056 | 0.002 | -0.001 | 0.981 | 0.012 | 0.877 |
| WASDE | 0.030 | 0.084 | -0.074 | 0.373 | 0.001 | 0.994 |
| **B. Live Cattle:** | | | | | | |
| Cattle | 0.134 | 0.000 | -0.023 | 0.713 | -0.038 | 0.614 |
| Cattle on Feed | 0.093 | 0.000 | 0.158 | 0.000 | 0.289 | 0.000 |
| Cold Storage | -0.008 | 0.127 | -0.042 | 0.266 | -0.135 | 0.007 |
| Hogs and Pigs | 0.134 | 0.000 | 0.169 | 0.000 | 0.183 | 0.000 |
| LDPO | -0.019 | 0.000 | -0.008 | 0.693 | -0.007 | 0.804 |
| WASDE | 0.024 | 0.000 | -0.086 | 0.001 | -0.057 | 0.088 |

Note: The dependent variable is the close-to-open, open-to-close, or close-to-close continuously compounded percentage return of live/lean hog or live cattle futures prices.

## Summary and Conclusions

This study investigated the value of USDA situation and outlook reports in hog and cattle markets. It is the first study to simultaneously consider the impact of all major public information reports in a commodity market. By including all major scheduled public announcements relevant to livestock markets, a comprehensive picture of the impact of public information in these markets is provided. The investigation is based on event study analysis, with the "events" consisting of the release of all major USDA situation and outlook reports for hogs and cattle: (*a*) Cattle; (*b*) Cattle on Feed; (*c*) Cold Storage; (*d*) Hogs and Pigs; (*e*) Livestock, Dairy, and Poultry Outlook (LDPO); and (*f*) World Agricultural Supply and Demand Estimates (WASDE). Daily futures returns from January 1985 through December 2004 are used in the analysis. The long sample period contains widely varying supply and demand conditions allowing for accurate estimation of information impacts.

A TARCH-in-mean model, with dummy variables to measure the impact of USDA reports and other external factors, was used to model daily close-to-open returns for live/lean hog and live cattle futures. This model closely followed the distribution of these daily return series and demonstrated that conditional variance in each market depended heavily on the previous day's variance and less on the long-run variance and new information. Consistent with previous findings in the finance and macroeconomics literature, this model also revealed that live/lean hog and live cattle return series reacted stronger to "bad" news than to "good" news. Based on the results of likelihood-ratio tests, USDA situation and outlook reports were shown to be a powerful and significant source of news in livestock markets.

The release of USDA reports was found to increase average conditional standard deviation of daily live/lean hog futures by as much as 96%, and of live cattle futures by as much as 37.5%. A statistically significant impact was identified for all but Cattle and Cold Storage reports in live/lean hog futures, and all but Cold Storage reports in live cattle futures. Hogs and Pigs reports had the largest impact on live/lean hog returns, while Cattle, Cattle on Feed, and Hogs and Pigs reports had the largest impact on the live cattle returns. The impact of Hogs and Pigs reports on live/lean hog returns was 16.6 to 31 times greater than the impact of outlook reports. Similarly, the impact of Cattle reports on live cattle prices was 5.5 times greater than the impact of WASDE reports. As suggested by these findings, the situation information has a much larger impact in livestock markets than outlook information.

Additional analysis was conducted to determine the sensitivity of results to the use of close-to-open returns compared to open-to-close returns and close-to-close returns. As predicted by market efficiency theory, the use of close-to-open returns to measure market impact proved to be the most accurate approach in a majority of cases. However, market impact was over-estimated using close-to-open returns for Hogs and Pigs reports in the hog market, and under-estimated for Cattle on Feed and Hogs and Pigs reports in the cattle market. Nonetheless, the exceptions did not fundamentally alter the conclusion that USDA reports were a powerful source of shocks to the normal movement of daily hog and cattle futures returns, thereby providing important new information to market participants. The sensitivity analysis did suggest that a complete understanding of the dynamics of market reaction to USDA reports requires the use of all three measures of returns.

The findings of this study are unique in terms of evaluation of USDA public information as a system. While our results provide strong evidence of the important economic role played by USDA situation and outlook reports in hog and cattle markets, it is important to keep in mind that the analysis is limited to the impact of USDA reports on nearby futures prices. Some of the information contained in the reports may have a larger impact on futures prices for deferred contracts due to production cycles which extend beyond near contract expectations. For example, Colling and Irwin (1990) found that changes in market hog inventories contained in Hogs and Pigs reports mostly affect nearby futures prices, while changes in breeding hog inventories mostly affect contracts expiring about one production cycle later (8 to 10 months). An investigation of the impact of USDA reports on deferred livestock futures prices is currently under way.

[*Received February 2006; final revision received June 2006.*]

## References

Akgiray, V. "Conditional Heteroscedasticity in Time Series of Stock Returns: Evidence and Forecasts." *J. Business* 62(1989):55–80.

Andersen, T. G., and T. Bollerslev. "Deutsche Mark-Dollar Volatility: Intraday Activity Patterns, Macroeconomic Announcements, and Longer Run Dependencies." *J. Finance* 53(1998):219–265.

Andersen, T. G., T. Bollerslev, F. X. Diebold, and C. Vega. "Micro Effects of Macro Announcements: Real-Time Price Discovery in Foreign Exchange." *Amer. Econ. Rev.* 93(2003):38–62.

Anderson, R. W. "Some Determinants of the Volatility of Futures Prices." *J. Futures Mkts.* 5(1985): 332–348.

Baur, R. F., and P. F. Orazem. "The Rationality and Price Effects of USDA Forecasts of Oranges." *J. Finance* 49(1994):681–696.

Bomfim, A. N. "Pre-Announcement Effects, News Effects, and Volatility: Monetary Policy and the Stock Market." *J. Banking and Fin.* 27(2003):133–151.

Campbell, J. Y., A. W. Lo, and A. C. MacKinlay. *The Econometrics of Financial Markets.* Princeton, NJ: Princeton University Press, 1997.

Colling, P. L., and S. H. Irwin. "The Reaction of Live Hog Futures Prices to USDA Hogs and Pigs Reports." *Amer. J. Agr. Econ.* 71(1990):84–94.

Engle, R. F. "Risk and Volatility: Econometric Models and Financial Practice." *Amer. Econ. Rev.* 94(2004):405–420.

Engle, R. F., and V. K. Ng. "Measuring and Testing the Impact of News on Volatility." *J. Finance* 48(1993):1749–1778.

Falk, B., and P. F. Orazem. "A Theory of Futures Market Responses to Government Crop Forecasts." Staff Paper Series No. 150, Dept. of Econ., Iowa State University, Ames, December 1985.

Fortenbery, T. R., and D. A. Sumner. "The Effects of USDA Reports in Futures and Options Markets." *J. Futures Mkts.* 13(1993):157–173.

Glosten, L. R., R. Jagannathan, and D. E. Runkle. "On the Relation Between the Expected Value and the Volatility of the Nominal Excess Return on Stocks." *J. Finance* 48(1993):1779–1801.

Grunewald, O., M. S. McNulty, and A. W. Biere. "Live Cattle Futures Response to Cattle on Feed Reports." *Amer. J. Agr. Econ.* 75(1993):131–137.

Hull, J. C. *Options, Futures, and Other Derivatives*, 4th ed. Upper Saddle River, NJ: Prentice-Hall, 2000.

Jones, C., and R. Lumsdaine. "Macroeconomic News and Bond Market Volatility." *J. Finan. Econ.* 47(1998):315–337.

Junkus, J. C. "Weekend and Day of the Week Effects in Returns on Stock Index Futures." *J. Futures Mkts.* 3(1986):397–407.

Just, D. R., S. A. Wolf, S. Wu, and D. Zilberman. "Consumption of Economic Information in Agriculture." *Amer. J. Agr. Econ.* 84(2002):39–54.

Just, R. E. "The Impact of Less Data on the Agricultural Economy and Society." *Amer. J. Agr. Econ.* 65(1983):872–881.

Kenyon, D., K. Kling, J. Jordan, W. Seale, and N. McCabe. "Factors Affecting Agricultural Futures Price Variance." *J. Futures Mkts.* 7(1987):73–91.

Li, L., and R. F. Engle. "Macroeconomic Announcements and Volatility of Treasury Futures." Unpub. Discussion Pap. No. 98-27, University of California, San Diego, 1998.

McKenzie, A. M., M. R. Thomsen, and B. L. Dixon. "The Performance of Event Study Approaches Using Daily Commodity Futures Returns." *J. Futures Mkts.* 24(2004):533–555.

Rucker, R. R., W. N. Thurman, and J. K. Yoder. "Estimating the Structure of Market Reaction to News: Information Events and Lumber Futures Prices." *Amer. J. Agr. Econ.* 87(2005):482–500.

Salin, V., A. P. Thurow, K. R. Smith, and N. Elmer. "Exploring the Market for Agricultural Economics Information: Views of Private Sector Analysts." *Rev. Agr. Econ.* 20(1998):114–124.

Sumner, D. A., and R. A. E. Mueller. "Are Harvest Forecasts News? USDA Announcements and Futures Market Reactions." *Amer. J. Agr. Econ.* 71(1989):1–8.

Taylor, S. *Modeling Financial Time Series.* New York: John Wiley, 1986.

Yang, S. R., and B. W. Brorsen. "Daily Futures Price Changes and Non-Linear Dynamics." *Structural Change and Econ. Dynamics* 5(1994):111–132.

Zakoian, J. M. "Threshold Heteroskedastic Models." *J. Econ. Dynamics and Control* 18(1994):931–955.