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

by

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Practitioner's Abstract

The economic value of public situation and outlook information has long been a subject of debate. The purpose of this study is to investigate the economic value of USDA reports in hog and cattle markets. The investigation is based on event study analysis, with the "events" consisting of the release of six major USDA situation and outlook reports for hogs and cattle from 1985 through 2003. These include Cattle, Cattle on Feed, Cold Storage, Hogs and Pigs, Livestock, Dairy and Poultry Outlook (LDPO), and World Agricultural Supply and Demand Estimates (WASDE) reports. As a result of the process of modeling volatility of hog and cattle prices, a TARCH-in-mean model was specified that closely followed the distribution of these price movements. The effects of external information were evaluated within this model using dummy variables in the variance equation. The analysis revealed a statistically significant impact of all but Cattle and Cold Storage reports on live/lean hog returns and all but LDPO reports on live cattle returns. Hogs and Pigs reports had the highest impact on live/lean hog returns by increasing average conditional standard deviation by 118.6% following the release of these reports. Cattle and Hogs and Pigs reports had the highest impact on live cattle returns by increasing average conditional standard deviation in both cases 44.8%. These results suggest that the information contained in USDA situation and outlook reports provides economically-valuable information to livestock market participants.

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 provided 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 provided 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)

In response to this ongoing debate, several empirical studies investigate the economic benefits of public information in agricultural markets (e.g., Fortenbery and Sumner, 1993; Sumner and Mueller, 1989; Colling and Irwin, 1990; 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: in an efficient market, if prices react to the announcement of information ("the event"), then the information is valuable to market participants (Campbell, Lo, and MacKinlay, 1997). With only a few exceptions, event studies find a significant market price reaction to the release of USDA reports. These results suggest that public information released by USDA generates economic welfare benefits.

The most significant limitation of the existing literature on the value of public information reports is that previous studies conduct a report-by-report analysis in a piecemeal fashion that does not allow comparison to the impact of other relevant reports. While most studies apply an event study approach, different methods and sample periods are utilized, which makes it difficult to compare results across studies. Often there is little emphasis on the magnitude of market impacts, as most previous studies concentrate on qualitative "yes/no" conclusions about the impact of public information. Finally, previous studies have not paid careful attention to the issue of "clustering" (a simultaneous release of several reports) on report 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 limitations of previous studies demonstrate a need for a more comprehensive investigation. The purpose of this study is to investigate the impact of all major public information announcements in hog and cattle futures markets from 1985 through 2003. This is the first study that simultaneously considers the market impact of all major public information reports in a commodity market. 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: Cattle, Cattle on Feed, Cold Storage, Hogs and Pigs, Livestock, Dairy and Poultry Outlook and World Agricultural Supply and Demand Estimates (WASDE). The long sample period contains widely-varying supply and demand conditions which allow accurate estimation of information impacts. The goal is to determine whether hog and cattle futures prices reacted to USDA report announcements. Daily futures returns from January 1985 through December 2003 are used in the analysis.

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 prices changes. Such price movements are typically characterized by non-normal, skewed distributions and non-linear dynamics in variance and sometimes in the mean, thus making traditional OLS regressions unsuitable for the analysis. ARCH-type models originally proposed by Engle (1982) have become a standard tool in futures return modeling as they take into account autoregressive dynamics in returns. This study investigates three types of autoregressive models (GARCH, GARCH-in mean, and TARCH-in-mean) in order to search for a best representation of volatility in daily returns of hog and cattle futures prices. The direct impact of USDA situation and outlook reports is estimated using the most representative autoregressive model and 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

Numerous USDA reports are devoted to describing situation and outlook information in livestock markets. This study concentrates on six major situation and outlook reports devoted to hogs and cattle: Cattle, Cattle on Feed, Cold Storage, Hogs and Pigs, Livestock, Dairy and Poultry Outlook, and World Agricultural Supply and Demand Estimates. This section provides a brief description of information content and release schedule for each report.

Cattle reports are published by National Agricultural Statistics Service, Agricultural Statistics Board 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 U.S.

Cattle on Feed (COF) reports are published by National Agricultural Statistics Service, Agricultural Statistics Board every month and concentrate on the inventory information for the US 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 by National Agricultural Statistics Service,[1] Agricultural Statistics Board, USDA, 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 by National Agricultural Statistics Service, Agricultural Statistics Board. However, the schedule changed to monthly releases from January 2001 through September 2003, after which they went back to a quarterly schedule. These reports present data on the U.S. pig crop for 16 major states and the U.S., including inventory number by class, weight group, and value of hogs and pigs, farrowings, and farrowing intentions. The December report includes the number of hog operations, percent of inventory by size groups, and the number of hog operations based on ownership at the U.S. level.

Livestock, Dairy and Poultry Outlook (formerly known as Livestock Situation and Outlook Report, further in this study referred to as LDPO) is published by the Economic Research Service, USDA. It 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). It is the only report that 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 by the World Agricultural Outlook Board, Office of the Chief Economist, USDA and provide a commodity-by-commodity and country-by-country (selected countries) marketing year balance sheet of supply, consumption, and stocks of major grains, soybeans and products, and cotton; and U.S. supply and use of sugar and livestock products. Thus, this report provides a great deal of outlook information in combination with production information available from NASS and FAS.

All these reports contain information pertaining to hog and cattle markets. The challenge of this study is to evaluate the impact of specific reports within the network of multiple reports.

Empirical Studies of the Value of Situation and Outlook Information

Theoretical models of the value of public situation and outlook programs reveal a mixed picture regarding their economic value (see Irwin et al. (2002) for a detailed discussion). Depending on assumptions about expectations formation by producers, learning, the cost of information and competition, public programs may have little value or substantial value. Hence, it is fundamentally an empirical question whether these programs do or do not improve economic welfare. A brief review of previous empirical studies on the value of public situation and outlook programs is presented in this section.

A limited number of studies attempt to provide direct empirical estimates of the welfare benefits of public situation and outlook information (Hayami and Peterson, 1972; Freebairn, 1976; Bradford and Kelejian, 1978; Antonovitz and Roe, 1984; McNulty, 1997). In these studies, a theoretical supply/demand structure for a market is proposed, parameter estimates are obtained, and then social welfare is estimated under different information or expectation assumptions. As a group, these empirical studies suggest the social welfare value of public situation and outlook information substantially exceeds the cost.

A much larger number of studies investigate the indirect welfare benefits of public situation and outlook programs. The evidence is indirect because measures indirectly related to welfare, such as price impact in futures markets, are examined. In addition, the cost of situation and outlook programs is not considered. Given the technical difficulties associated with direct welfare estimation, it is probably not surprising that most empirical studies of the value of situation and outlook information use the indirect approach. Nearly all empirical studies of the indirect type use a variant of event study methodology. The basic notion of an event study is simple: in an efficient market, if prices react to the announcement of information ("the event"), then the information is valuable to market participants (Campbell, Lo, and MacKinlay, 1997). This event study framework can be illustrated nicely using the following diffusion process for futures prices,

$$\frac{dP_{t+1}}{P_t} = \mu dt + \sigma dz \tag{1}$$

where P_t is the futures price on day t, μ is referred to as the expected rate of return, σ is price volatility, and dz is a generalized Wiener process (Hull, 2000, p. 216) of returns and time. Because the parameters of this model are unobserved, it is unclear whether new information impacts price changes through the first or the second right-hand side term, or some combination of both.

Most previous studies are not specific about the underlying model being tested and tend to implicitly concentrate only on the first or the second term of the model listed above. For example, a number of previous studies (e.g., Sumner and Mueller, 1989; Fortenbury and Sumner, 1993; Mann and Dowen, 1997; Irwin et al., 2002) assume that new information impacts the volatility of market prices. Figure 1 illustrates price reaction to news announcements in terms of instantaneous volatility, which is characterized by a spike in volatility on the announcement date as opposed to constant volatility on non-announcement dates. These studies implicitly assume that there is no mean price reaction to news announcements. The findings of these studies are surprisingly consistent given the variety of sample periods and test procedures used. With only a few exceptions, studies find a significant price reaction in futures markets to the release of USDA situation reports.

Another group of studies assume that new information affects the expected returns of market prices and leave out any volatility reaction. These studies examine the impact of new information within the constant mean return framework, which compares the return (percentage price change) on the event date with an established baseline, typically called a "normal return." Previous studies that utilized this approach include Milonas (1987), Shroeder, Blair, and Mintert (1990), Mann and Dowen (1997), and McKenzie and Thomsen (2001). These studies generally find limited evidence of the impact of new information on market prices. The limitation of this approach is that market reaction in terms of mean returns is detectable only when reports are classified as bullish or bearish, otherwise return reactions offset each other. This limitation is overcome in the studies that use expectations information to determine market reaction. This approach is based on the notion that market prices react to the "surprise" component of public information. The surprise component is typically calculated as the difference between the published information and the expectation of this information. Previous studies that have applied this approach (e.g., Colling and Irwin, 1990; Grunewald, McNulty, and Biere, 1993; Garcia et al., 1997) typically use industry analyst's pre-release estimates as a proxy of market expectations of government reports. Regression equations are estimated in this approach with price changes after reports specified as a function of the market surprises. Most of these studies find significant impact of unanticipated information contained in USDA forecasts on market prices. While, these studies are able to provide information about the magnitude of the impact of new information on market prices and solve the problem of offsetting market reactions, they still assume no volatility reaction.

A final group of studies implicitly combine mean and volatility reactions by testing the market impact of public information based on implied volatility reaction in options markets (Fortenbery and Sumner, 1993; McNew and Espinosa, 1994; Irwin et al., 2002). The implied volatility is a measure of volatility which makes a model option price equal the observed option price (Ho and Lee, 2004). Thus, the implied volatility concept impounds both mean reaction and volatility changes around the event. However, this framework does not allow disentangling these two types (mean and variance) of reaction. The pattern that researchers are looking for in terms of implied volatilities is a rise before the announcement date, a peak on the day before the announcement and a fall to its long-term level on the report date (as shown in Figure 2). In general, the findings of studies that employ implied volatility tests indicate a significant reaction to public information.

In this study we attempt to follow the diffusion process of futures prices model and propose a framework that takes into account both the mean and variance components of price reactions. However, in the absence of expectations data, which would allow classification of reports as bullish or bearish, our ability to detect mean reaction is limited. Therefore, we concentrate on determining the variance reaction to public information.

Data

The "events" to be analyzed in this study include the release of all major USDA Reports for livestock and hog markets from January 2, 1985 through December 23, 2003.[2] Typically, these reports were issued at 3:30 pm. EST after the end of the daily trading session at the Chicago Mercantile Exchange. The only exception being WASDE reports which changed their release schedule from the afternoon following the close of trading to the morning before the start of trading in May 1994. Because we are interested in the market reaction to these reports, the events include the trading session immediately following the report release. Thus, this analysis includes trading sessions on the day following the release of all of the reports, except for WASDE reports after May 1994, for which trading on the day of the release is used.

Overall, 970 reports were released during the 4,792 days from January 2, 1985 to December 23, 2003. This illustrates the presence of public information in the cattle and hog markets, as a major situation and/or outlook report was released on average every five days. The monthly reports, COF, CS, and WASDE, were published 228 times during the study period, while the other reports were released less often: LDPO 153 times; HPR 97 times; and Cattle 38 times. Availability of multiple reports resulted in clustering when several reports were released on the same day. That is, 970 reports were released on 830 days. The reports most affected by clustering were Cattle, COF, and CS reports as these were often released simultaneously. Clustering was taken into account in this study by inclusion of all relevant reports into a time series model, which allows for the separate impact of clustered reports to be estimated.

Returns are calculated as log (continuously compounded) percent daily changes in the nearby futures contract prices for hogs and cattle during the period from January 2, 1985 through December 23, 2003. 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 December 1996 and lean hog futures prices from January 1997 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 on a close-to-open basis as,

(2) $$R_{t,i} = \ln(p_{t,i}^{o} / p_{t-1,i}^{c}) \cdot 100$$

where $p_{t,i}^{o}$ is the opening price of the nearest-to-maturity futures contract for session *t* and commodity *i*, $p_{t-1,i}^{c}$ is the closing price of the nearest-to-maturity futures contract for session *t-1* and commodity *i*, and ln is the natural logarithm function. 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 that the impact of USDA reports, if any, should be reflected instantaneously in futures prices as soon as a trading session begins. Therefore, close-to-open price changes that span the release time of USDA reports will best reflect the immediate reaction of cattle and hog 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.[3]

The analysis of daily futures price reactions in hog and cattle markets is complicated by the presence of limits which restrict futures price movements. The futures prices restricted by limit moves may not adequately represent market prices on the days with limit moves thereby causing potential problems for empirical analysis. Historically, prices of live hog contracts were limited at $1.50 per contract and prices of lean hog futures at $2.00 per contract. During the period of study live/lean hog futures prices were subject to limit moves on the close-to-open basis a total of 35 times. Prices of live cattle futures contracts were subject to limit moves on a close-to-open basis a total of 21 times. Thus the incidence of limit moves in our sample is very small, 0.7% for live/lean hog futures and 0.4% for live cattle futures. This suggests that the potential impact of limit moves in the empirical analysis is quite small. Furthermore, McKenzie, Thomsen, and Dixon (2004) argue that there is little concern that the existence of price limits leads to Type II errors in the analysis of hog and cattle futures returns. In other words, failure to detect price reaction when it in fact exists. They demonstrate that for large sample sizes abnormal performance is detected at levels well below 1% and for the smaller samples at about 1.5%. These levels of abnormal returns are well within the range of price limits specified for the contracts over the study period. These arguments indicate that price limits may not have significant impact on the analysis conducted in this study. Sensitivity analysis for data sets that exclude price limit days is used to confirm this argument.

Statistical Analysis

Characteristics of Hog and Cattle Futures Returns

Close-to-open percentage returns of daily live/lean hog and live cattle futures are plotted in Figures 3 and 4, 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 new information. This study hypothesizes that at least some of this new information becomes available from USDA situation and outlook reports. Live/lean hog futures returns are in general more volatile than live cattle returns. Figures 5 and 6 present volatility of live/lean hog and live cattle futures markets 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 2003. 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 percent return volatility of live/lean hog and live cattle futures are presented 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 three times greater than that of live cattle returns. This table also shows that on report days the volatility of live/lean hog returns, in terms of absolute value, was 37% greater and the volatility of live cattle returns was 45% greater relative to non-report days. The largest volatility in the live/lean hog markets was associated with the HPR reports followed by the CS, LDPO, COF, WASDE, and Cattle report. Live cattle markets were most affected by the Cattle reports followed by the COF, HPR, Cold Storage, LDPO, and WASDE reports. This data presents 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.

Modeling Futures Returns

In order to determine the impact of USDA report announcements on livestock markets, an appropriate framework for modeling daily futures returns should be selected. Futures return movements are typically characterized by non-normal, skewed distributions and non-linear dynamics in variance and sometimes in mean, thus making traditional OLS regressions unsuitable for their analysis. The breakthrough in modeling daily price changes was made with the development of ARCH models by Engle (1982), which take into account autoregressive dynamics in returns. The ARCH model describes return variance in terms of weighted averages of past squared errors, a type of weighted variance. Since the 1980s, numerous extensions of ARCH models have been proposed. The most popular has been the GARCH(1,1) model proposed by Bollerslev (1986), which became a benchmark for modeling financial asset return volatility. GARCH essentially generalizes the purely autoregressive ARCH model to an autoregressive moving average model where the weights on past squared residuals are assumed to decline geometrically at a rate estimated from the data. The basic form of a GARCH(1,1) process is,

(3)
$$R_t = x_t'\varphi + \varepsilon_t, \text{ where } \varepsilon_t \left| \psi_{t-1} \sim N(0, h_t^2) \right.$$
$$h_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta h_{t-1}^2.$$

Setting $\omega = \vartheta V$ the variance equation of this model can be rewritten as,

(4)
$$h_t^2 = \vartheta V + \alpha\varepsilon_{t-1}^2 + \beta h_{t-1}^2.$$

This formulation demonstrates that the conditional variance of the GARCH process is calculated as a weighted average of the long run average variance rate, V, the previous forecast, h_{t-1}^2, and the news measured as a square of yesterday's return, ε_{t-1}^2. This model requires the weights to sum up to one: $\vartheta + \alpha + \beta = 1$, implying that ϑ can be calculated as 1-α-β and the long term variance, V, can then be calculated as ω / ϑ (Hull, 2000, p.373).

Previous empirical studies demonstrated the presence of small positive autocorrelation in agricultural futures return series (e.g., Taylor, 1986; Yang and Brorsen, 1994). This characteristic is typically accounted for by including lagged values of returns in the mean equation, with at least 10 lags,

(5)
$$R_t = \varphi_0 + \sum_{s=1}^{10} \varphi_s y_{t-s} + \varepsilon_t, \text{ where } \varepsilon_t \left| \psi_{t-1} \sim N(0, h_t^2) \right.$$
$$h_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta h_{t-1}^2.$$

The constant term (φ_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 level of variance of returns. The effects of conditional variance on the mean term may be modeled by including the conditional standard deviation into the mean equation,

(6)
$$R_t = \varphi_0 + \sum_{s=1}^{n} \varphi_s y_{t-s} + \varphi_{s+1} h_t + \varepsilon_t, \text{ where } \varepsilon_t \left| \psi_{t-1} \sim N(0, h_t^2) \right.$$
$$h_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta h_{t-1}^2.$$

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 that negative returns had more than three times the effect of positive returns on future variances of the S&P 500 index. This evidence is consistent with recent theories developed in the behavioral finance literature about how individuals react to "good" and "bad" news. This asymmetry may be modeled using an asymmetric volatility model referred to as GJR-GARCH for Glosten et al. (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"),

(7)
$$R_t = \varphi_0 + \sum_{s=1}^{n} \varphi_s y_{t-s} + \varphi_{s+1} h_t + \varepsilon_t, \text{ where } \varepsilon_t \left| \psi_{t-1} \sim N(0, h_t^2) \right.$$
$$h_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \gamma\varepsilon_{t-1}^2 I_{\varepsilon_{t-1}<0} + \beta h_{t-1}^2.$$

This formulation redistributes the weights for the calculation of conditional variance into $1-\alpha-\beta-\gamma/2$, β, $\alpha/2$, and $(\alpha+\gamma)/2$ for the unconditional variance, the previous forecast, the good news and the bad news, respectively. The weights for α 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. 412-13). This TARCH model represents the current state of knowledge about the volatility of financial return series. However, this model is not exhaustive. While capturing the general path of "normal" return volatility it does not account for the shocks that may cause abnormal movements. The effects of external factors on volatility of futures returns series are discussed in the following section.

The Impact of External Factors on Volatility of Futures Returns

While the autoregressive models provide an appropriate framework of modeling financial return series, they have not been able to fully describe the underlying return generating process. The challenge in the recent financial literature has been to provide a complete model which includes all external effects. Some of the most common external effects include day-of-the-week effects (e.g., Junkus, 1986; Yang and Brorsen, 1994; Li and Engle, 1998) and seasonality in variance (Anderson, 1985; Kenyon et al., 1987; Yang and Brorsen, 1994). The most interesting external effects are news announcements (e.g., Li and Engle, 1998; Andersen, et al., 2003; Bomfim, 2003). The goal of this study is to examine the effect of USDA report announcements in hog and cattle markets. This effect can be measured correctly only if a full, well-specified model is used.

The impact of the external effects typically is introduced using dummy variables in the mean and/or variance equations. This study hypothesizes that the day-of-the-week has an affect on both mean and variance, while seasonality and USDA report announcements have an affect on variance only. Hence, the full model is specified as,

(8)
$$R_t = \varphi_0 + \sum_{s=1}^{10} \varphi_s y_{t-s} + \varphi_{11} h_t + \varphi_{12} D_M + \varphi_{13} D_T + \varphi_{14} D_W + \varphi_{15} D_H + \varepsilon_t$$

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

where the dummy variables for each day of the week are D_M=1 if Monday and 0 otherwise, and so on (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_{CST} 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 is a Friday in December when no reports were released.

The parameter estimates on the dummy variables indicate a change in the RHS due to the event indicated with a dummy relative to the reference point.[4] In other words, they describe shocks in return volatility caused by respective external effects. The other parameter estimates of this model provide information about the components of the "normal" level of volatility. The constant in the mean equation (φ_0) is interpreted as a constant price of risk, the sum of φ_0 and φ_{11} represents a variable price of risk, and the parameters on lagged returns measure autocorrelation. Estimates of α, γ, and β for the variance equation are used to calculate the impact of the long-term variance, the previous forecast, and the good and the bad news on conditional variance as discussed above. The estimate of ω is used to calculate the long-term variance, which is equal to $\omega/(1-\alpha-\beta-\gamma/2)$. The parameter estimates for each commodity were obtained using E-Views econometric software.

Modeling Results

Tables 3 and 4 present the results of the process of modeling "normal" daily changes in live/lean hog and live cattle futures returns over 1985 through 2003. The starting point for this process is a GARCH model with 10 lags of past returns in the mean equation. This model appears to represent the movements in live/lean hog and live cattle futures returns reasonably well because all relevant parameters as well as the F-statistic for the entire model are statistically significant. The improvement of the model by introduction of a variance measure in the mean equation resulted in a significant GARCH-in mean term for live/lean hog returns and insignificant term for live cattle returns. The difference in statistical significance of this term most likely reflects the difference in the overall level of variance of the two commodities as there may simply not be enough variation in cattle returns to significantly alter the mean of these returns. Finally the TARCH model is estimated to capture the asymmetry of market reaction to different types of news. Consistent with previous findings in financial markets, daily live/lean hog and cattle futures tend to have a stronger reaction to negative news than to positive news. Thus, the estimated TARCH models assign weights of 0.022 and 0.0485 to positive and negative news, respectively, in the hog market; and weights of 0.0155 and 0.0275 to positive and negative news in the cattle market. Overall, this process resulted in a consistent improvement of the proposed model; reflected in significant parameter estimates and F-statistics accompanied by improvements in the log likelihood.

The results of this analysis of "normal" movements in futures returns based on the TARCH estimates suggest that the price of risk of hog futures returns was a constant of -0.12 plus a variable component of 0.17. These estimates imply that daily live/lean hog futures returns increase by 0.17 percentage points in response to each percentage point increase in conditional standard deviation of these returns. Cattle futures returns did not exhibit enough variability to generate an estimate of the price of risk (both constant and in-mean terms are statistically insignificant). Autocorrelation seems to be dominant in the first two lags for hogs and the first four lags for cattle. The variance estimates suggest that the conditional variance of live/lean hog futures places a weight of about 4% on the long run unconditional variance (which is equal to 0.50), a weight of 2% on prior day's good news about volatility, a weight of 5% on the bad news about volatility and a weight of about 89% on the prior day's conditional variance estimate. The conditional variance estimate of live cattle futures returns places a weight of about 1% on the long run unconditional variance (which is equal to 0.17), a weight of 3% on the prior day's good news about volatility, a weight of 1% on the bad news about volatility and a weight of about 95% on prior day's conditional variance estimate.

The second part of empirical analysis in this study was devoted to the investigation of the impact of external factors on daily volatility of live/lean hogs and live cattle futures. The external factors considered in this study were the day-of-the-week effects, seasonality effects, and USDA report announcement effects. Tables 5 and 6 report the results of this analysis for hogs and cattle respectively. The day-of-the-week effects appear stronger on the variance level then on the mean level. Overall relevance of the day-of-the-week effects is indicated by the significant value of the likelihood ratio tests. The next equation adds the seasonality effects, which are also important based on the results of likelihood ratio tests. Finally, the inclusion of USDA report effects results in further improvement of the likelihood ratio, suggesting that these effects also are statistically significant.

The results based on the full system TARCH estimation 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 0.10 percentage points in hog futures markets. Thus, while these are statistically significant, the magnitudes are quite small. Hog futures markets were also slightly less volatile on Tuesdays. Without showing statistical differences in returns, cattle futures markets tended to be more volatile on Mondays and Wednesdays than the rest of the week. Seasonality effects were observed in the variance of live cattle futures returns but not in live/lean hog futures returns. Cattle futures returns appeared less volatile in February, March, April, June, and July and more volatile in May, October and November relative to December. USDA reports had the strongest impact on the volatility of returns of both commodities. The remainder of this section offers a graphical and quantitative interpretation of these results.

TARCH estimates of the conditional variance of the live/lean hog and live cattle futures returns are presented graphically in Figures 7 and 8, respectively. These estimates may be compared with the daily squared returns presented in Figures 5 and 6. This comparison allows us to conclude that we are correctly explaining most of the "normal" variation in these returns as well as picking up most of the "shocks" in these return volatilities. This graphical analysis suggests that our statistical models adequately represent movements in daily live/lean hog and live cattle futures returns. However, one caveat of our statistical approach should be mentioned. Because of the underlying model design (particularly its 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 is not always consistent with actual movements of these return series. This limitation of the model may have caused us to overestimate the "normal" volatility of these returns and underestimate the statistical significance of our "shock" coefficients. This limitation should be considered for the following discussion of the quantitative impact of USDA reports and other external effects.

Impact of USDA Reports

The results of this study demonstrate that USDA reports were the most powerful source of shocks to the "normal" movements of daily hog and cattle futures returns. The total impact of USDA reports as a system is reflected in a much higher value of the likelihood ratio in both commodities. The release of USDA reports increased conditional variance of live/lean hog futures by a factor as large as 0.98 and of live cattle futures by a factor as large as 0.12 (Tables 5 and 6, respectively). While the magnitude of these effects may appear small in absolute value, they should be interpreted relative to average variance of the daily futures price 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:

(9)
$$\frac{\partial h_t}{\partial D_i} = \frac{\partial h_t}{\partial h_t^2} \times \frac{\partial h^2}{\partial D_i} = \frac{1}{2h_t} \times \delta_i = \frac{\delta_i}{2h_t}$$

This formula is evaluated using the δ_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 7, the average conditional standard deviation of live/lean hog returns was 0.645%/day and of live cattle returns 0.368%/day. These results may be interpreted in absolute terms based on the average daily futures price of lean hogs during the period of study of about $62/cwt. and the average price of live cattle at $70/cwt. Specifically, in dollar terms the daily conditional standard deviation was $0.40/cwt. for lean hogs and $0.26/cwt. for live cattle futures.

The other variables presented in Table 7 need to be interpreted carefully. To begin, $\hat{\delta}_i$ is the increase in conditional variance ($\hat{h}_t^2$) associated with a particular external event. 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 is 0.035, which indicates that the conditional standard deviation of live/lean hog futures increased 0.035 percentage points on Cattle report release dates. The third variable in each set of results is likely the most meaningful from an economic perspective. It is simply 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. Results for this variable show that conditional standard deviation of live/lean hog futures was 4.2% greater on the days following the release of Cattle reports. Similarly, the conditional standard deviation of live cattle futures returns was 44.8% greater on the days of release of Cattle reports.

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 data presented in Table 7 indicates that day-of-the-week and seasonality effects were generally smaller in magnitude than USDA report effects, thus, leading to a conclusion that USDA reports had the strongest impact on volatility of returns in both commodities. Furthermore, our model allows comparison of the relative importance of situation and outlook information released by USDA. The LDPO and WASDE reports are considered outlook reports, while the other reports are described as situation or inventory reports. The results presented in Table 7 indicate that situation information has a much stronger impact on return volatility than outlook information. While the impact of outlook information in live/lean hogs is greater than the day-of-the-week and seasonality impacts, the impact of outlook information in live cattle is not very strong and generally comparable to the impact of other external factors.

Finally, the results of this study may be interpreted on the level of specific reports. The Hogs and Pigs reports had the largest impact in the hog market and Hogs and Pigs and the Cattle reports had the largest impact in the cattle market. Conditional standard deviation of lean hog futures was 118.6% greater on the days following the release of Hogs and Pigs reports, or about $0.75/cwt. in absolute terms. Conditional standard deviation of live cattle futures returns was 44.8% greater on the days following Hogs and Pigs or Cattle reports, or about $0.37/cwt. in absolute terms. The impact of the other reports and combinations of reports may be interpreted in similar manner from the results presented in Table 7. No significant impact of Cattle or Cold Storage reports was detected in hog markets. Cattle markets were significantly affected by all but LDPO reports.

The sensitivity of these results to price limit moves was tested by deleting observations that included price limit moves. Thus, for the days that hit the limit, the next non-limit open price was used, thereby omitting limited price movements. The results of this sensitivity analysis are presented in Table 8. The results presented in Table 8 are comparable to full system estimations for respective commodities from Tables 5 and 6. Overall, the two sets of results are consistent. These results support our earlier conjecture that the presence of limit moves has minimal effects on the analysis of the response of futures prices to public information in hog and cattle markets.

Summary and Conclusions

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 provided by public programs and evolving priorities within the USDA. In response to this ongoing debate, a large number of empirical studies investigate the economic benefits of public information (e.g. Crop Production Reports and Hogs and Pigs Reports). However, previous studies conduct a report-by-report analysis in a piecemeal fashion which does not provide a picture of the total impact of public information as a system or the relative importance of different reports. Often there is little emphasis on the magnitude of market impacts. Finally, previous studies have not paid careful attention to the issue of "clustering" (a simultaneous release of several reports) on report days or during the same reaction window.

This study investigates the impact of all major USDA situation and outlook information in hog and cattle futures markets from 1985 through 2003. This is the first study that simultaneously considers the market impact of all major public information reports in a commodity market. 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: Cattle, Cattle on Feed, Cold Storage, Hogs and Pigs, Livestock, Dairy and Poultry Outlook (LDPO), and World Agricultural Supply and Demand Estimates (WASDE). The long sample period contains widely-varying supply and demand conditions which allow accurate estimation of information impacts. The goal is to determine whether hog and cattle futures prices reacted to USDA report announcements. Daily futures returns from January 1985 through December 2003 are used in the analysis.

The statistical analysis employed in the paper consists of the process of modeling daily volatility of futures return series for live/lean hogs and live cattle and examination of the impact of external information on volatility. In order to correctly measure the impact of USDA outlook information on daily hog and cattle returns, these price movements should be correctly modeled. As a result of the process of modeling volatility of hog and cattle returns, a TARCH-in-mean model was specified that closely followed the distribution of these daily price movements. The effects of external information were evaluated within this model using dummy variables. This modeling effort generated evidence on the impact of the day-of-the-week and seasonality effects in cattle and hog return series as well as USDA reports.

The general results of TARCH model estimation demonstrate that conditional variance of hog and cattle return series depend mostly on the previous variance forecast and much less on the long-run unconditional variance and new information. The analysis of the impact of the external factors revealed statistically significant impacts day-of-the-week, seasonality and USDA reports on the returns of both commodities. The results of this study demonstrate that USDA reports were the most powerful source of shocks to the "normal" movements of daily hog and cattle futures returns. The release of USDA reports resulted in increases in average conditional standard deviation of daily live/lean hog futures (0.64%/day) by as much as 118.6% and of live cattle futures (0.37%/day) by as much as 44.9%.

In relative terms, USDA report impacts were in general much larger in magnitude then other external factors included in this study thus leading us to a conclusion that USDA reports had the strongest impact on volatility of daily returns in both commodities. Comparison of the impact of USDA situation and outlook information revealed a more substantial impact of situation information. The impact of outlook information in live/lean hogs was greater than the day-of-the-week and seasonality impacts, the impact of outlook information in live cattle was not very strong and generally comparable to the impact of other external factors.

On the specific report level, the Hogs and Pigs reports had the largest impact in the hog market and the Cattle reports had the largest impact in the cattle market. The conditional standard deviation of lean hog futures was 118.6% greater on the days following the release of Hogs and Pigs reports, or about $0.75/cwt. in absolute terms. The conditional standard deviation of live cattle futures returns was 44.8% greater on the days following Hogs and Pigs or Cattle reports, or about $0.37/cwt. in absolute terms. In both markets, the release of Hogs and Pigs report had the largest impact, and the release of Cold Storage reports had the smallest impact.

While the findings of this study are unique in terms of evaluation of USDA public information as a system and relative importance of this information, the general results concerning specific reposts are consistent with the previous research (e.g., Irwin et al), that demonstrates the significant impact of USDA situation and outlook information in other agricultural markets. The results of this study suggest that the information contained in USDA reports provides economically-valuable information for livestock market participants.

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Endnotes

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

[2] The last few days in 2003 were excluded due to the unusual volatility associated with the mad cow scare.

[3] This point can be illustrated with a simple example. First, decompose the variance of close-to-close price changes as follows,

$$\mathrm{var}(cc) = \mathrm{var}(co) + \mathrm{var}(oc) + 2\,\mathrm{cov}(co, oc)$$

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,

$$\mathrm{var}(cc) = \mathrm{var}(co) + \mathrm{var}(oc).$$

Now, define the variances on normal days versus report days as,

	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 fifty percent 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 percent 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 fifty percent compared to 16.7 percent.

[4] 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.

Table 1. Futures Contracts Used in Market Reaction Tests

Month of Report Release	Live/Lean Hogs 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

Note: All contracts refer to Chicago Mercantile Exchange futures.

Table 2. Descriptive Statistics for Daily Hog and Cattle Futures Price Return Volatility, January 1985-December 2003.

	Hogs		Cattle	
Sample/Report	$\lvert \overline{R}_t \rvert$	$\overline{R}_t^2$	$\lvert \overline{R}_t \rvert$	$\overline{R}_t^2$
Full Sample	0.474	0.512	0.263	0.159
Cattle	0.395	0.382	0.608	0.693
Cattle on Feed	0.528	0.520	0.542	0.538
Cold Storage	0.555	0.628	0.379	0.349
Hogs and Pigs	1.533	3.946	0.477	0.485
LDPO	0.519	0.575	0.332	0.238
WASDE	0.453	0.453	0.252	0.145
All Report Days	0.610	0.916	0.349	0.272
Non-Report Days	0.445	0.431	0.240	0.126

Note: R_t is the daily continuously compounded percentage return of live/lean hog and live cattle futures prices.

Table 3. Modeling "Normal" Daily Movements of Live/Lean Hogs Futures Returns, January 1985 - December 2003.

Parameter	GARCH Model		GARCH-in Mean Model		TARCH Model	
	Mean Equation					
	Coefficient	Prob	Coefficient	Prob	Coefficient	Prob
SQR(GARCH)			0.183	0.01	0.167	0.01
Constant	-0.017	0.07	-0.128	0.00	-0.123	0.00
y_{t-1}	0.161	0.00	0.159	0.00	0.165	0.00
y_{t-2}	-0.054	0.00	-0.055	0.00	-0.052	0.00
y_{t-3}	0.024	0.13	0.023	0.16	0.024	0.12
y_{t-4}	0.000	1.00	-0.001	0.93	0.000	0.99
y_{t-5}	0.029	0.06	0.029	0.06	0.030	0.05
y_{t-6}	0.004	0.81	0.002	0.87	0.001	0.93
y_{t-7}	0.021	0.16	0.020	0.19	0.019	0.21
y_{t-8}	0.015	0.34	0.014	0.36	0.013	0.39
y_{t-9}	0.031	0.04	0.031	0.04	0.030	0.04
y_{t-10}	0.017	0.25	0.017	0.26	0.015	0.32
	Variance Equation					
Constant	0.022	0.00	0.022	0.00	0.021	0.00
ARCH(1)	0.074	0.00	0.075	0.00	0.044	0.00
(RESID<0)*ARCH(1)					0.053	0.00
GARCH(1)	0.882	0.00	0.880	0.00	0.887	0.00
	Diagnostics					
R-squared	0.031		0.034		0.034	
Adjusted R-squared	0.028		0.031		0.031	
S.E. of regression	0.705		0.704		0.704	
Sum squared resid	2369.170		2362.669		2361.061	
Log likelihood	-4722.626		-4721.218		-4709.646	
Durbin-Watson stat	1.960		1.961		1.967	
Mean dependent var	-0.020		-0.020		-0.020	
S.D. dependent var	0.715		0.715		0.715	
Akaike info criterion	1.981		1.981		1.977	
Schwarz criterion	2.000		2.002		1.999	
F-statistic	11.783		11.906		11.334	
Prob(F-statistic)	0.000		0.000		0.000	

Table 4. Modeling "Normal" Daily Movements of Live Cattle Futures Returns, January 1985 - December 2003.

Parameter	GARCH Model		GARCH-in Mean Model		TARCH Model	
	Mean Equation					
	Coefficient	Prob	Coefficient	Prob	Coefficient	Prob
SQR(GARCH)			0.072	0.20	0.077	0.16
Constant	0.001	0.84	-0.022	0.24	-0.026	0.16
y_{t-1}	0.129	0.00	0.128	0.00	0.128	0.00
y_{t-2}	0.091	0.00	0.091	0.00	0.092	0.00
y_{t-3}	0.041	0.01	0.041	0.01	0.042	0.01
y_{t-4}	0.040	0.01	0.040	0.01	0.040	0.01
y_{t-5}	0.009	0.54	0.008	0.58	0.011	0.47
y_{t-6}	-0.011	0.50	-0.012	0.47	-0.010	0.56
y_{t-7}	0.003	0.85	0.003	0.85	0.005	0.75
y_{t-8}	0.007	0.67	0.006	0.68	0.008	0.61
y_{t-9}	0.009	0.55	0.010	0.54	0.015	0.35
y_{t-10}	0.004	0.78	0.003	0.83	0.002	0.87
	Variance Equation					
Constant	0.002	0.00	0.002	0.00	0.002	0.00
ARCH(1)	0.045	0.00	0.046	0.00	0.031	0.00
(RESID<0)*ARCH(1)					0.024	0.00
GARCH(1)	0.942	0.00	0.941	0.00	0.945	0.00
	Diagnostics					
R-squared	0.026		0.027		0.027	
Adjusted R-squared	0.024		0.025		0.024	
S.E. of regression	0.394		0.393		0.393	
Sum squared resid	738.309		737.447		737.453	
Log likelihood	-1861.137		-1863.199		-1858.228	
Durbin-Watson stat	1.990		1.992		1.991	
Mean dependent var	0.007		0.007		0.007	
S.D. dependent var	0.398		0.398		0.398	
Akaike info criterion	0.784		0.786		0.784	
Schwarz criterion	0.803		0.806		0.806	
F-statistic	9.911		9.610		8.965	
Prob(F-statistic)	0.000		0.000		0.000	

Table 5. Modeling the Impact of External Factors on Daily Live/Lean Hog Futures Returns, January 1985 - December 2003.

Parameter	Full System		Day-of-Week and Seasonality Included		Day-of-Week Included	
	Mean Equation					
	Coefficient	Prob	Coefficient	Prob	Coefficient	Prob
SQR(GARCH)	0.106	0.03	0.109	0.04	0.162	0.01
Constant	-0.035	0.26	-0.046	0.19	-0.086	0.06
y_{t-1}	0.153	0.00	0.154	0.00	0.162	0.00
y_{t-2}	-0.043	0.01	-0.044	0.01	-0.050	0.00
y_{t-3}	0.026	0.10	0.022	0.16	0.029	0.07
y_{t-4}	0.016	0.29	0.002	0.89	-0.001	0.96
y_{t-5}	0.021	0.16	0.018	0.24	0.027	0.08
y_{t-6}	0.008	0.57	0.003	0.83	0.009	0.57
y_{t-7}	0.007	0.60	0.019	0.21	0.021	0.15
y_{t-8}	0.015	0.27	0.014	0.35	0.020	0.19
y_{t-9}	0.032	0.01	0.028	0.06	0.025	0.10
y_{t-10}	0.009	0.51	0.005	0.71	0.009	0.53
D (Monday)	-0.060	0.02	-0.065	0.02	-0.059	0.05
D (Tuesday)	-0.061	0.02	-0.045	0.10	-0.038	0.19
D (Wednesday)	-0.103	0.00	-0.082	0.00	-0.080	0.01
D (Thurday)	-0.011	0.65	0.005	0.86	0.020	0.50
	Variance Equation					
Constant	0.029	0.01	0.038	0.00	0.037	0.00
ARCH(1)	0.058	0.00	0.022	0.00	0.042	0.00
(RESID<0)*ARCH(1)	0.095	0.00	0.050	0.00	0.066	0.00
GARCH(1)	0.803	0.00	0.928	0.00	0.878	0.00
D (Monday)	0.016	0.39	0.058	0.00	0.070	0.00
D (Tuesday)	-0.053	0.00	-0.058	0.00	-0.141	0.00
D (Wednesday)	-0.011	0.53	-0.031	0.05	-0.064	0.00
D (Thurday)	-0.012	0.54	0.003	0.86	0.073	0.00

Table 5 (continued). Modeling the Impact of External Factors on Daily Live/Lean Hog Futures Returns, January 1985 - December 2003.

Parameter	Full System		Day-of-Week and Seasonality Included		Day-of-Week Included
	Variance Equation				
	Coefficient	Prob	Coefficient	Prob	
D (January)	-0.011	0.03	-0.031	0.00	
D (February)	0.000	0.94	-0.023	0.00	
D (March)	0.017	0.00	-0.005	0.08	
D (April)	-0.003	0.49	-0.031	0.00	
D (May)	-0.002	0.70	-0.028	0.00	
D (June)	-0.001	0.85	0.006	0.03	
D (July)	-0.004	0.46	-0.033	0.00	
D (August)	0.005	0.35	-0.027	0.00	
D (September)	0.000	0.93	-0.004	0.21	
D (October)	0.007	0.22	-0.027	0.00	
D (November)	0.002	0.71	-0.032	0.00	
D (Cattle)	0.035	0.32			
D (Cattle on Feed)	0.050	0.01			
D (Cold Storage)	0.004	0.83			
D (Hogs and Pigs)	0.981	0.00			
D (LDPO)	0.047	0.01			
D (WASDE)	0.049	0.01			
	Diagnostics				
R-squared	0.038		0.038		0.039
Adjusted R-squared	0.030		0.031		0.034
S.E. of regression	0.703		0.703		0.702
Sum squared resid	2345.330		2345.505		2343.019
Log likelihood	-4360.085		-4530.326		-4626.933
Durbin-Watson stat	1.947		1.952		1.962
Mean dependent var	-0.019		-0.019		-0.020
S.D. dependent var	0.714		0.714		0.715
Akaike info criterion	1.841		1.910		1.949
Schwarz criterion	1.897		1.958		1.981
F-statistic	4.657		5.475		8.340
Prob(F-statistic)	0.000		0.000		0.000
LR test	340.482		193.214		165.426
Prob(LR test)	0.000		0.000		0.000

Table 6. Modelling the Impact of External Factors on Daily Live Cattle Futures Returns, January 1985 - December 2003.

Parameter	Full System		Day-of-Week and Seasonality Included		Day-of-Week Included	
	Mean Equation					
	Coefficient	Prob	Coefficient	Prob	Coefficient	Prob
SQR(GARCH)	0.072	0.08	0.091	0.05	0.094	0.07
Constant	-0.021	0.08	-0.025	0.08	-0.028	0.13
y_{t-1}	0.148	0.00	0.131	0.00	0.128	0.00
y_{t-2}	0.085	0.00	0.089	0.00	0.090	0.00
y_{t-3}	0.031	0.07	0.042	0.01	0.042	0.01
y_{t-4}	0.034	0.02	0.039	0.01	0.037	0.02
y_{t-5}	0.007	0.65	0.005	0.75	0.007	0.65
y_{t-6}	-0.012	0.40	-0.012	0.46	-0.010	0.56
y_{t-7}	0.008	0.52	0.011	0.45	0.003	0.85
y_{t-8}	0.005	0.70	0.001	0.97	0.004	0.81
y_{t-9}	0.008	0.55	0.016	0.32	0.015	0.34
y_{t-10}	0.002	0.87	0.003	0.83	0.002	0.89
D (Monday)	-0.018	0.22	-0.024	0.11	-0.018	0.21
D (Tuesday)	0.011	0.41	0.006	0.68	0.010	0.50
D (Wednesday)	0.004	0.77	-0.002	0.89	-0.004	0.82
D (Thurday)	-0.009	0.51	-0.009	0.51	-0.007	0.64
	Variance Equation					
Constant	-0.004	0.19	-0.012	0.00	-0.014	0.00
ARCH(1)	0.097	0.00	0.040	0.00	0.038	0.00
(RESID<0)*ARCH(1)	0.054	0.00	0.034	0.00	0.033	0.00
GARCH(1)	0.791	0.00	0.921	0.00	0.926	0.00
D (Monday)	0.028	0.00	0.057	0.00	0.043	0.00
D (Tuesday)	-0.004	0.36	-0.004	0.31	0.000	0.99
D (Wednesday)	0.034	0.00	0.033	0.00	0.034	0.00
D (Thurday)	-0.007	0.15	0.003	0.47	0.011	0.00

Table 6 (continued). Modelling the Impact of External Factors on Daily Live Cattle Futures Returns, January 1985 - December 2003.

Parameter	Full System		Day-of-Week and Seasonality Included		Day-of-Week Included
	Variance Equation				
	Coefficient	Prob	Coefficient	Prob	
D (January)	0.000	0.83	0.002	0.04	
D (February)	-0.003	0.03	0.000	0.87	
D (March)	-0.003	0.04	-0.004	0.00	
D (April)	-0.003	0.09	-0.002	0.01	
D (May)	0.009	0.00	0.000	0.49	
D (June)	-0.005	0.00	-0.002	0.00	
D (July)	-0.005	0.00	-0.002	0.00	
D (August)	-0.001	0.60	-0.003	0.00	
D (September)	0.001	0.73	0.004	0.00	
D (October)	0.009	0.00	-0.004	0.00	
D (November)	-0.006	0.00	-0.005	0.00	
D (Cattle)	0.121	0.00			
D (Cattle on Feed)	0.092	0.00			
D (Cold Storage)	-0.012	0.02			
D (Hogs and Pigs)	0.121	0.00			
D (LDPO)	0.000	0.98			
D (WASDE)	0.017	0.00			
	Diagnostics				
R-squared	0.028		0.028		0.029
Adjusted R-squared	0.020		0.021		0.024
S.E. of regression	0.394		0.394		0.393
Sum squared resid	734.086		736.930		736.453
Log likelihood	-1684.063		-1768.028		-1819.382
Durbin-Watson stat	2.032		1.997		1.990
Mean dependent var	0.007		0.007		0.007
S.D. dependent var	0.398		0.398		0.398
Akaike info criterion	0.722		0.754		0.771
Schwarz criterion	0.777		0.802		0.804
F-statistic	3.449		4.041		6.125
Prob(F-statistic)	0.000		0.000		0.000
LR test	167.930		102.708		77.692
Prob(LR test)	0.000		0.000		0.000

Table 7. Impact of External Factors on Daily Conditional Standard Deviation of Live/Lean Hog and Live Cattle Futures Returns, January 1985 - December 2003.

	Live/Lean Hogs			Live Cattle		
Mean Conditional Standard Deviation $(\hat{h}_t)$	0.643 %/day			0.368 %/day		
	$\hat{\delta}_i$	$\partial\hat{h}_t/\partial D_i$	Proportion of mean $\hat{h}_t$	$\hat{\delta}_i$	$\partial\hat{h}_t/\partial D_i$	Proportion of mean $\hat{h}_t$
D (Monday)	0.016	0.013	2.0%	0.028	0.038	10.3%
D (Tuesday)	-0.053	-0.041	-6.4%	-0.004	-0.006	-1.5%
D (Wednesday)	-0.011	-0.008	-1.3%	0.034	0.047	12.7%
D (Thurday)	-0.012	-0.010	-1.5%	-0.007	-0.010	-2.7%
D (January)	-0.011	-0.009	-1.3%	0.000	0.000	-0.1%
D (February)	0.000	0.000	0.0%	-0.003	-0.005	-1.3%
D (March)	0.017	0.013	2.1%	-0.003	-0.004	-1.1%
D (April)	-0.003	-0.002	-0.4%	-0.003	-0.003	-0.9%
D (May)	-0.002	-0.001	-0.2%	0.009	0.012	3.4%
D (June)	-0.001	-0.001	-0.1%	-0.005	-0.007	-1.8%
D (July)	-0.004	-0.003	-0.5%	-0.005	-0.007	-1.8%
D (August)	0.005	0.004	0.6%	-0.001	-0.001	-0.3%
D (September)	0.000	0.000	0.1%	0.001	0.001	0.2%
D (October)	0.007	0.005	0.8%	0.009	0.013	3.5%
D (November)	0.002	0.002	0.2%	-0.006	-0.008	-2.1%
D (Cattle)	0.035	0.027	4.2%	0.121	0.165	44.8%
D (Cattle on Feed)	0.050	0.039	6.0%	0.092	0.126	34.1%
D (Cold Storage)	0.004	0.003	0.5%	-0.012	-0.016	-4.4%
D (Hogs and Pigs)	0.981	0.763	118.6%	0.121	0.165	44.8%
D (LDPO)	0.047	0.037	5.7%	0.000	0.000	-0.1%
D (WASDE)	0.049	0.038	5.9%	0.017	0.023	6.4%

Table 8. Modeling the Impact of External Factors on Daily Live/Lean Hog and Live Cattle Futures Returns Excluding Price Limit Moves, January 1985 - December 2003.

Parameter	Live/Lean Hogs		Live Cattle	
	Mean Equation			
	Coefficient	Prob	Coefficient	Prob.
SQR(GARCH)	0.102	0.06	0.052	0.27
Constant	-0.032	0.35	-0.020	0.15
y_{t-1}	0.131	0.00	0.136	0.00
y_{t-2}	-0.034	0.04	0.084	0.00
y_{t-3}	0.015	0.36	0.031	0.05
y_{t-4}	0.021	0.19	0.022	0.18
y_{t-5}	0.015	0.29	-0.001	0.97
y_{t-6}	0.007	0.66	0.010	0.51
y_{t-7}	0.017	0.21	0.017	0.25
y_{t-8}	0.022	0.10	0.019	0.20
y_{t-9}	0.038	0.01	0.011	0.47
y_{t-10}	0.005	0.72	-0.005	0.71
D (Monday)	-0.058	0.03	0.002	0.89
D (Tuesday)	-0.057	0.03	0.013	0.36
D (Wednesday)	-0.102	0.00	0.004	0.79
D (Thurday)	-0.016	0.53	-0.002	0.90
	Variance Equation			
Constant	0.054	0.00	-0.006	0.05
ARCH(1)	0.071	0.00	0.096	0.00
(RESID<0)*ARCH(1)	0.068	0.00	0.019	0.16
GARCH(1)	0.789	0.00	0.833	0.00
D (Monday)	-0.028	0.15	0.027	0.00
D (Tuesday)	-0.047	0.01	0.009	0.04
D (Wednesday)	-0.047	0.00	0.011	0.02
D (Thurday)	-0.032	0.10	0.007	0.12

Table 8 (continued). Modeling the Impact of External Factors on Daily Live/Lean Hog and Live Cattle Futures Returns Excluding Price Limit Moves, January 1985 - December 2003.

Parameter	Live/Lean Hogs		Live Cattle	
	Variance Equation			
	Coefficient	Prob	Coefficient	Prob.
D (January)	-0.011	0.03	0.000	0.75
D (February)	-0.003	0.64	0.001	0.26
D (March)	0.013	0.01	-0.004	0.00
D (April)	-0.005	0.28	-0.002	0.13
D (May)	-0.004	0.35	0.002	0.09
D (June)	-0.003	0.59	-0.003	0.00
D (July)	-0.001	0.85	-0.004	0.00
D (August)	0.004	0.48	0.002	0.20
D (September)	-0.003	0.59	0.000	0.76
D (October)	0.009	0.11	0.008	0.00
D (November)	0.001	0.87	-0.004	0.00
D (Cattle)	0.009	0.79	0.022	0.09
D (Cattle on Feed)	0.043	0.04	0.064	0.00
D (Cold Storage)	-0.006	0.78	-0.003	0.50
D (Hogs and Pigs)	0.957	0.00	0.099	0.00
D (LDPO)	0.059	0.00	-0.007	0.16
D (WASDE)	0.035	0.06	0.005	0.27
	Diagnostics			
R-squared	0.022		0.018	
Adjusted R-squared	0.014		0.010	
S.E. of regression	0.669		0.362	
Sum squared resid	2081.550		603.839	
Log likelihood	-4163.713		-1447.725	
Durbin-Watson stat	2.013		2.061	
Mean dependent var	-0.018		0.004	
S.D. dependent var	0.673		0.364	
Akaike info criterion	1.791		0.642	
Schwarz criterion	1.847		0.699	
F-statistic	2.613		2.148	
Prob(F-statistic)	0.000		0.000	

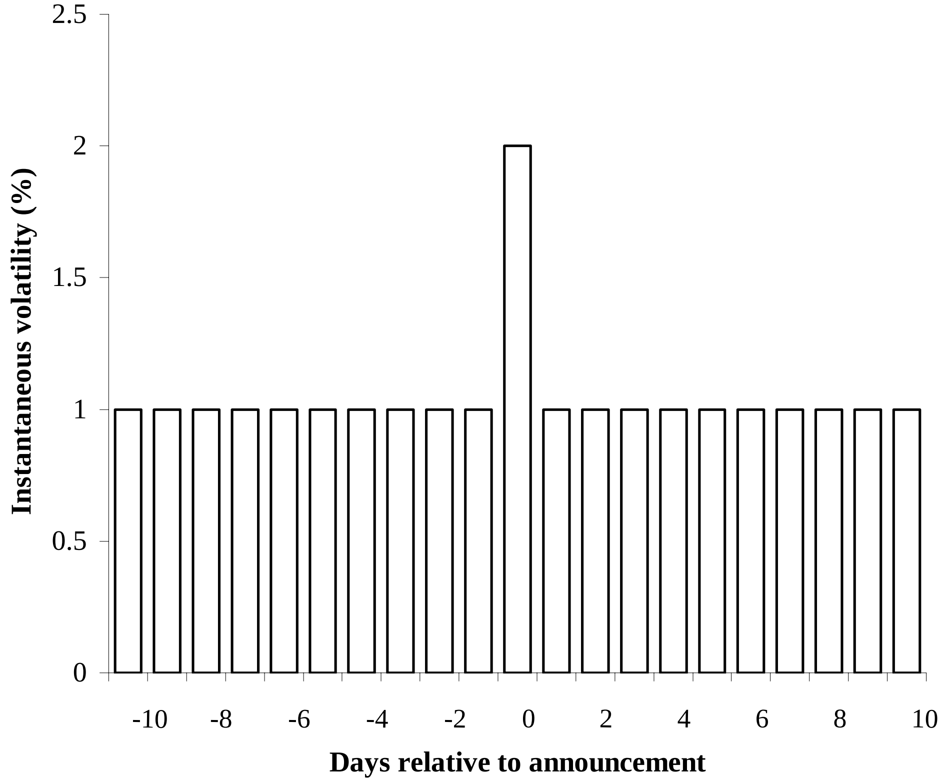

Figure 1. Evolution of Instantaneous Volatility around News Announcements.

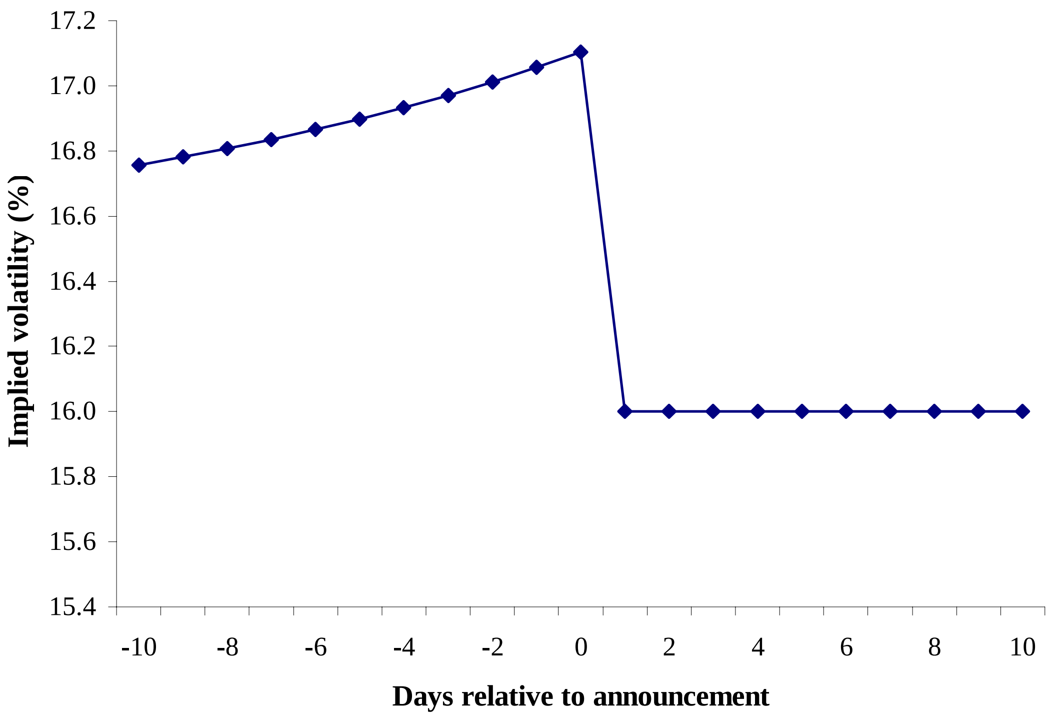

Figure 2. Evolution of Implied Volatility around News Announcements.

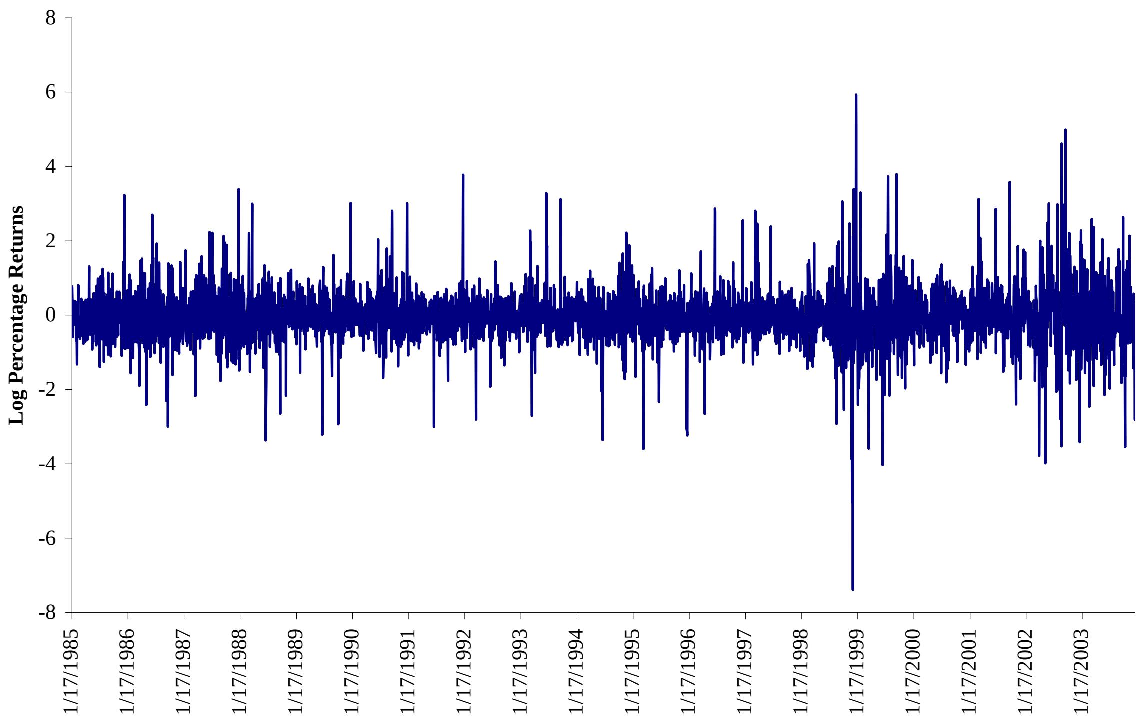

Figure 3. Daily Live/Lean Hog Futures Returns, January 1985-December 2003

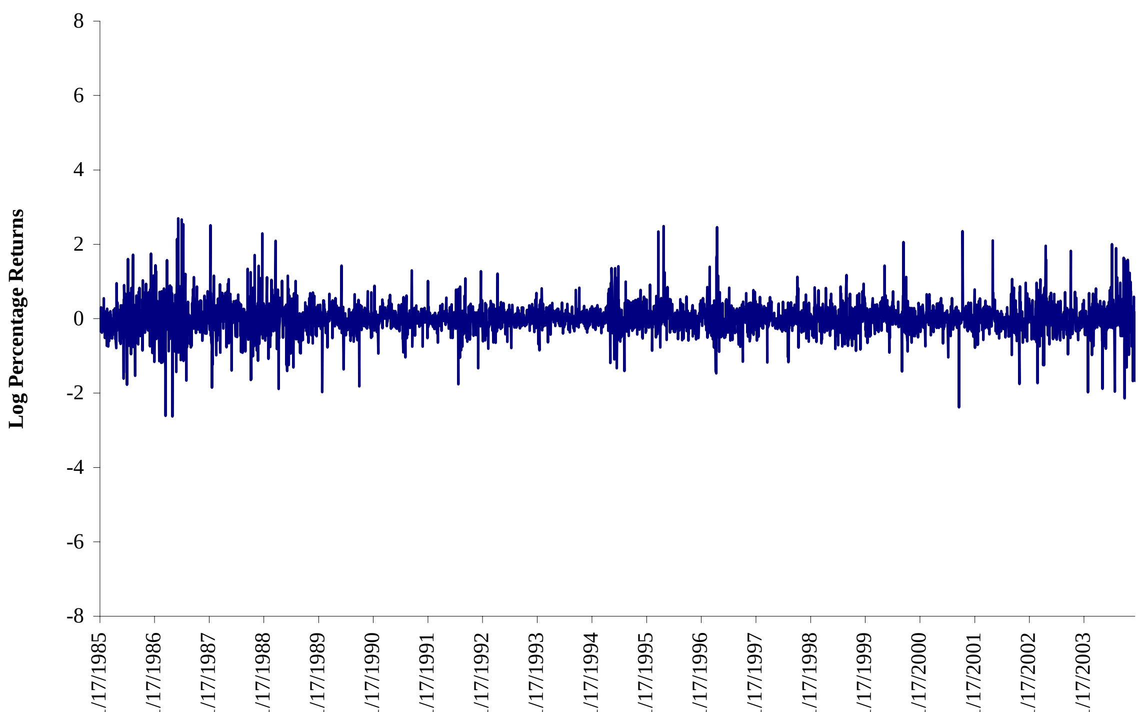

Figure 4. Daily Live Cattle Futures Returns, January 1985-December 2003

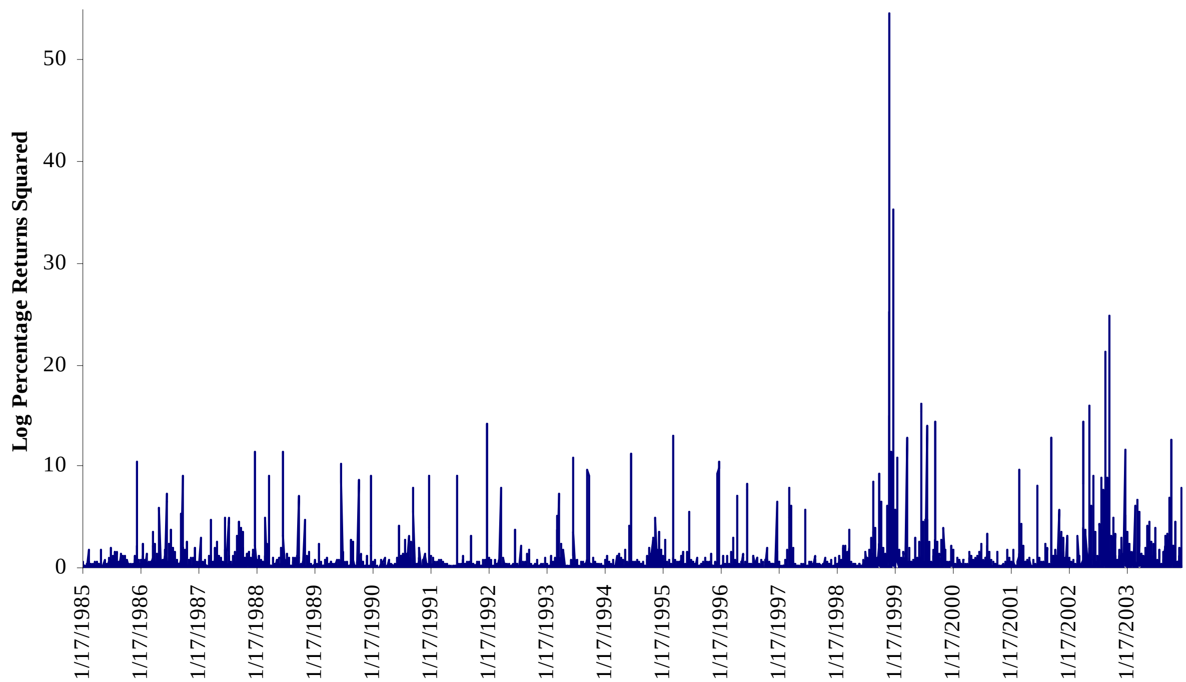

Figure 5. Daily Live/Lean Hog Futures Squared Returns, January 1985-December 2003

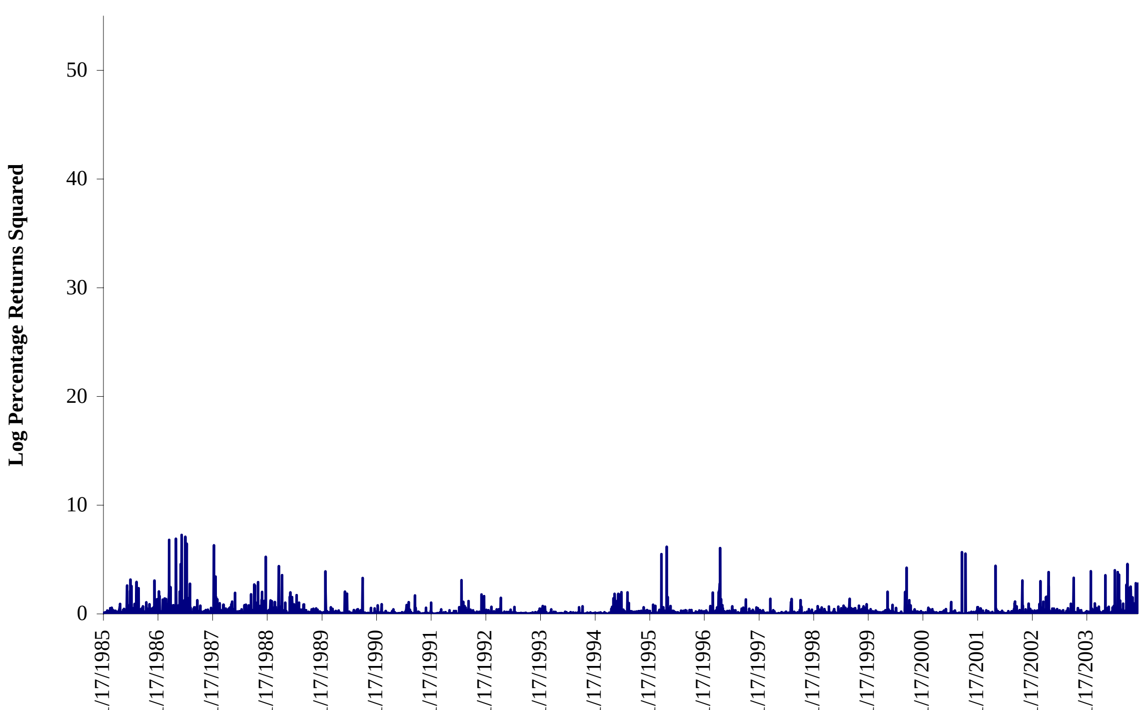

Figure 6. Daily Live Cattle Futures Squared Returns, January 1985-December 2003

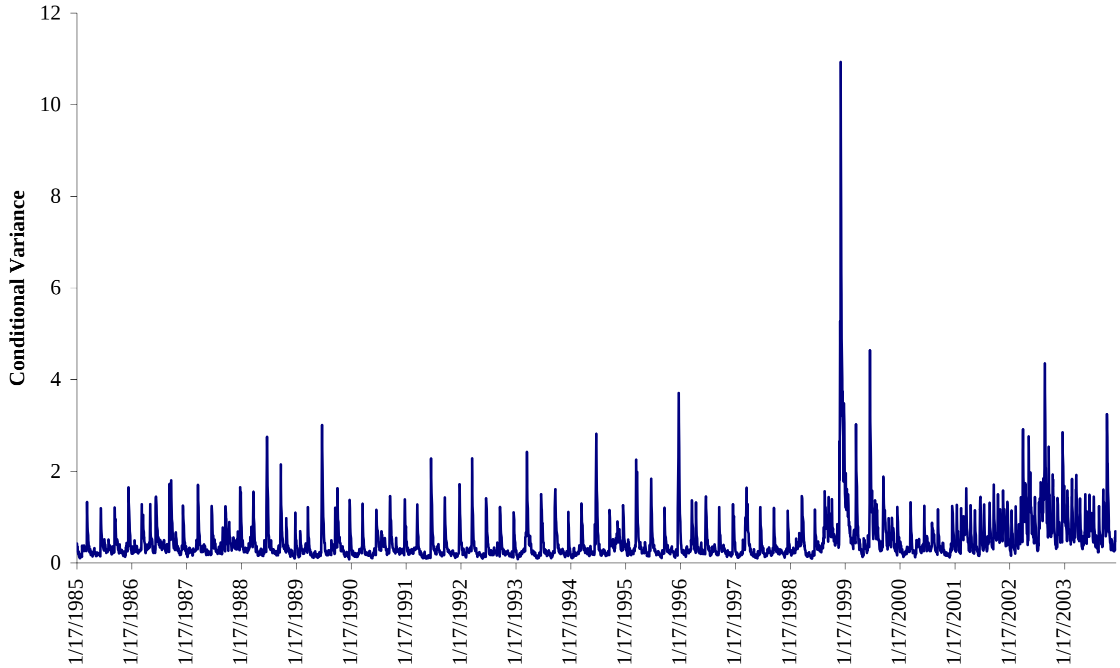

Figure 7. Estimated Daily Conditional Variance of Live/Lean Hog Futures Returns, January 1985-December 2003

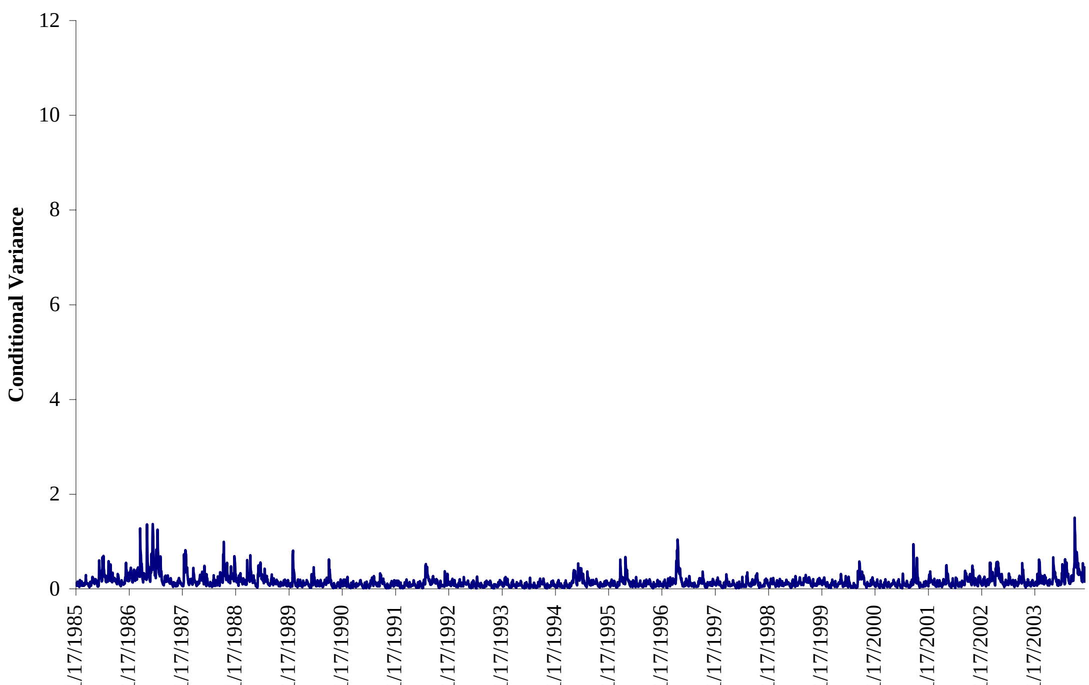

Figure 8. Estimated Daily Conditional Variance of Live Cattle Futures Returns, January 1985-December 2003.