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Berna Karali, Olga Isengildina-Massa,
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Do Livestock Markets Still Value USDA Information?

Berna Karali, Olga Isengildina-Massa, and Scott H. Irwin[1]

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[1] Berna Karali is an Associate Professor in the Department of Agricultural and Applied Economics at the University of Georgia. Olga Isengildina-Massa is an Associate Professor in the Department of Agricultural and Applied Economics at Virginia Tech University. Scott H. Irwin is the Lawrence J. Norton Chair of Agricultural Marketing in the Department of Agricultural and Consumer Economics at the University of Illinois at Urbana-Champaign.

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Practitioner's Abstract

The informational value of U.S. Department of Agriculture (USDA) livestock reports for cattle and hogs futures markets is analyzed to determine potential impact of increased market concentration seen in the livestock industry over the last three decades. Both market surprises, the difference between the USDA's and private analysts' forecasts, and price reactions to those surprises are analyzed for possible changes over time using sub-period analysis and rolling-window regressions. The results suggest that while the market surprise component of the reports decreased over time for both Cattle on Feed and Hogs and Pigs reports, the price reaction to those surprises increased in the early 2000s, suggesting that USDA reports still provide valuable information to market participants beyond private analysts' expectations.

Key words: announcement effects, cattle, futures markets, hogs, informational value, price reaction, USDA reports.

Introduction

Livestock sectors have undergone major structural changes since late 1980s with increased vertical integration accompanied with spot market transactions being replaced with marketing and production contracts. For example, the four-firm concentration ratio (CR4) measuring the four largest firms' share in total slaughter increased from 36% in 1980 to 85% in 2012 for steer and heifer, and from 34% to 64% for hogs (MacDonald 2017). Furthermore, while there were 145 steer and heifer slaughtering plants in 1975-1976 with the five largest plants having a 14.8% share in total slaughter, there were only 36 plants in 2006-2007 with the 14 largest plants holding a 70.2% share (Ward 2010). Similarly, 235,000 hog farms maintained 67% of total hog inventories and 87% of hogs were sold via spot market in 1993, there were 63,000 farms in 2009-2010 with 43% of share in hog inventories and only 8% of hogs were sold through spot market (Lawrence 2010).

This dramatic shift toward a highly concentrated industry led the livestock sector to be termed as a thin market, which is characterized by farmers' limited selling opportunities to one or few potential buyers. Three main concerns associated with thin markets are that prices might be (1) highly volatile; (2) manipulated by firms through contracts; and (3) departing from competitive levels (Adjemian, Saitone, and Sexton 2016). While previous studies documented production efficiency gains attained from these structural changes (Key and McBride 2003; MacDonald and McBride 2009), the question of market efficiency and the value of public information in a thin market remains to be answered.

The United States Department of Agriculture's (USDA) reports have been historically the predominant source of public information on commodities and shown to contain informational

value.[1] However, higher market concentration may deteriorate the value of USDA information because larger firms have better access to market data as well as better analytic ability to process it. In fact, there is some evidence (Isengildina-Massa et al. 2016) that the value of USDA reports is increasing in the crop markets but decreasing in the livestock markets. This raises the question: Does the value of USDA reports still exist when a sector is moved to a vertically integrated structure?

Therefore, the goal of this study is to assess relative performance and changes in market impact of USDA reports relevant to the livestock markets. In particular, we focus on the impact of Cattle on Feed and Hogs and Pigs reports, which play a key role in livestock markets and are widely watched by market participants.[2] While there are various studies on the value of these reports in livestock futures markets (e.g., Hoffman 1980; Colling and Irwin 1990; Colling, Irwin, and Zulauf 1997; Isengildina, Irwin, and Good 2006; Schaefer, Myers, and Koontz 2004; Frank, Garcia, and Irwin 2008), it is not yet known how the impact of these reports has changed over time, especially in the era of highly concentrated livestock markets.

Relative performance is assessed by examining "market surprise" defined as the percentage difference between the USDA estimates and the private analysts' expectations. To identify possible improvements in private forecasts, we test the equality of means and variances of market surprises over time using Student's t and Brown-Forsythe tests. Smaller, less variable surprises would indicate that the ability of private analysts to anticipate USDA information has improved. Price reaction tests use market surprise as a measure of new information contained in USDA reports and evaluate the change in futures prices in response to market surprise (Colling and Irwin 1990; Garcia et al. 1997). These tests are performed using a generalized autoregressive conditional heteroskedasticity (GARCH) model of futures returns, and changes in market reaction are assessed across sub-periods identified by the Bai-Perron structural break tests and by estimating 10-year rolling GARCH models. Declining price responses would indicate that the livestock market became prone to USDA information.

Our results suggest that while the market surprise component of the reports decreased over time for both Cattle on Feed and Hogs and Pigs reports, the price reaction to those surprises increased in the early 2000s. Both of these findings point to better quality of private forecasts, improvement of which could be due to increased private information sources or increased industry concentration in the 1980s and 1990s. However, better private information does not erase the value of USDA's livestock reports as they continue to significantly affect futures prices in both cattle and hog markets, indicating that both reports still provide valuable information to market participants beyond private analysts' expectations.

[1] See, for example, Sumner and Mueller (1989), Fortenbery and Sumner (1993), Grunewald, McNulty, and Biere (1993), Garcia et al. (1997), McKenzie (2008), Karali (2012).

[2] The surveys by Pruitt et al. (2012, 2013), for instance, show that while livestock extension agents ranked Cattle on Feed as the second and Hogs and Pigs as the eight most useful report, market analysts and/or agribusiness professionals regarded Cattle on Feed as valuable and Hogs and Pigs as more valuable.

Overview of Structural Changes in Livestock Markets

Cattle and hog production and marketing practices in the Unites States have changed dramatically over the last three decades. Ward (2010) reports that in 1976, there were 145 steer and heifer slaughtering plants with annual slaughter of 50,000 head or more, and the largest five plants accounted for 14.8% of slaughter by all firms. The number of plants in the 50,000 head or more category declined to 36 in 2006, and the largest 14 plants accounted for 70.2% of total slaughter. Average slaughter per plant increased from 666,800 head in 1976 (in the five largest plants) to 1,302,643 head in 2006 (in the 14 largest plants). Mergers and acquisitions in cattle sector increased the CR4 ratio of 25% in 1976 to 67% in 1987, to 80% in 1993, and to 85% in 2012.

Hog slaughtering sector followed a similar trend, but the changes were not as dramatic. Lawrence (2010) states that in 1993, there were 235,000 hog farms and 67% of total hog inventories in the Unites States were on farms with less than 2,000 hogs. In 2009, on the other hand, there were 63,000 farms holding 43% of total hog inventories. The remaining 57% were owned by 13 producers with 50,000 head or more hogs. The CR4 increased from 34% in 1980 to 64% in 2012 (MacDonald 2017).

Livestock procurement practices have also shifted from spot markets to contractual agreements within the supply chain. While 87% of hogs were sold in spot markets in 1993, the share of spot market sales decreased to 17% in 2002, and to 8% in 2009 (Lawrence 2010; Saitone and Sexton 2017). The 49% of hogs were sold through forward or formula contract in 2009. The shift in cattle sector was more gradual. The spot market share of cattle sales decreased 43.8% in 2001-2002 to 34.1% in 2009-2010, while the forward contract share increased from 3% to 10.3%. Figure 1 summarizes the key structural changes in cattle and hog markets.

Data

USDA Estimates

USDA's livestock inventory estimates for cattle and hogs are contained in Cattle on Feed and Hogs and Pigs reports. Cattle on Feed reports are published monthly by the National Agricultural Statistics Service (NASS) agency of USDA. The reports contain data on the total number of cattle and calves on feed, placements, marketings, and other disappearances. These reported categories are closely related as on-feed inventory numbers are stocks at a particular point in time, placements are additions to these stocks, and marketings and other disappearances are reductions in these stocks. Therefore, the difference between the on-feed numbers from the beginning of one month to the next reflects the on-feed inventory from the previous month, plus placements, less marketings and other disappearances (Mark and Small, 2007). The reports are typically released at 3:00pm EST[3] on the third Friday of the month and contain data as of the beginning of the month. The information in these reports is based on the survey of feedlots in

[3] There were couple of exceptions due to USDA's release schedule before the holidays. Cattle on Feed report in December 2005 was released at 1:00pm EST, and May 2015 and December 2016 reports were released at 12:00pm EST.

major cattle feeding states[4] in the U.S., representing about 98 percent of total U.S. production.[5] Consequently, these reports provide information on current and future cattle supplies to market participants.

Hogs and Pigs reports are also prepared by NASS and released quarterly. These reports provide data on the U.S. pig crop for major producing states and the entire U.S., including inventory number by category, weight group, and value of hogs and pigs, farrowings, and farrowing intentions. The two main categories of the hogs and pigs inventories are breeding herd and market hogs. The reports also include the number of operations keeping hogs, the number of hog operations, and percent of inventory by size groups. The reports are typically released at 3:00pm EST[6] on Friday near the end of March, June, September, and December (i.e. the first month of each quarter) and present inventory data as of the first day of the month and the previous and future quarters.[7] These reports provide quarterly inventory estimates for the major hog producing states[8] which account for about 95 percent of total U.S. production. The reports also aggregate the remaining states to generate the U.S. total, thereby providing the most comprehensive publicly available estimates of current and future hog supplies (Small, Waterbury, and Mark 2007).

Private Analysts' Estimates

Industry analysts' estimates, which are usually released a few days before the USDA reports, are frequently used as a proxy for market expectations of government reports (e.g., Colling and Irwin 1990; Grunewald, McNulty, and Biere 1993; Garcia et al. 1997; Egelkraut et al. 2003). Private analysts' expectations for Cattle on Feed reports, available from 1977, are obtained from Knight-Ridder Wire Service and Bridge Wire Service for the period 1977-2000, and from Oster Dow Jones and Dow Jones for the period 2000-2017. The expectations are reported as the average trade guess of cattle on feed, placements, and marketings for the current quarter as a percentage of the comparable month a year ago. Private analysts' expectations of Hogs and Pigs reports, available from 1982, are obtained from various sources: Futures World News for 1982-1991, Knight-Ridder Wire Service for 1992-2000, Reuters (Bridge) and Dow Jones Newswire for 2000-2004 and December 2006, Dow Jones Newswire for 2005-2013, and Urner-Barry 2015-2017. The expectations are reported as the average trade guess of the breeding and marketing inventory for the current quarter as a percentage of the comparable quarter a year ago.

[4] The USDA's definition of feedlots included in the survey has changed over time. The data set is composed of inventory levels in all feedlots in seven states through December 1994, the feedlots that have at least 1,000 head of cattle in seven states from January 1995 to October 1998, and those 1,000+ capacity feedlots in the U.S. thereafter.
[5] For more information, please see Mark and Small (2007).
[6] Hogs and Pigs report was released at 1:00pm EST in December 2011, and at 12:00pm EST in March and December 2016 due to the USDA's release schedule before the holidays.
[7] The release schedule of Hogs and Pigs report has changed to monthly from January 2001 through September 2003, after which quarterly schedule was resumed. Only quarterly reports are included in our study.
[8] The USDA's definition of major states has changed over time as some states have experienced a great expansion of hog production, while others have become less important in the hog industry. The data set is composed of 14 states through March 1982, 10 states from June 1982 to March 1996, 17 states from June 1996 to September 2009, and 16 states thereafter.

For both reports, we multiply year-ago inventory levels by the analysts' expected percentage of year-ago figures. This provides us the market analysts' expectations in terms of the number of cattle and hogs, making them comparable to USDA figures.

Futures Prices

We use daily data for nearby futures contracts of live cattle and lean hogs, both are traded at the Chicago Board of Trade (CBOT) from 9:30am EST to 2:05pm EST. To match the availability of private analysts' forecasts, futures data are collected starting in 1977 for live cattle and 1982 for lean hogs. The hog series uses live hog futures prices through November 1996 and lean hog futures prices from December 1996 onward. Nearby series are constructed by rolling over to the second closest to expiration contract once that next contract has a trade volume exceeding the nearest delivery contract. Due to relatively low trading volume, we eliminate May contract for lean hogs. Table 1 lists the specific futures contract maturities used in each calendar month for the nearby futures price series.

Figure 2 shows daily close-to-close returns for live cattle and lean hogs nearby futures contracts. The returns of both commodities are characterized by consistent normal volatility which is interrupted by volatility spikes. This study hypothesizes that at least some of these spikes can be traced to new information in USDA situation and outlook reports. Furthermore, volatility of both commodities appears to change over time with live cattle return volatility being higher prior to 1990 and after 2003. Lean hog volatility appears to be much higher in the second half of the sample starting in 1998. These graphs also demonstrate the non-linear dynamics in futures returns, which make traditional ordinary least squares (OLS) regressions unsuitable for their analysis (e.g., Yang and Brorsen 1994). Therefore, GARCH models are used in our analysis to provide an adequate representation of the distribution of daily futures returns.

Changes in Market Surprises over Time

Market surprise reflects the new information contained in the USDA announcement and calculated as the percentage difference between the USDA estimate $q_t^{k,U}$ for category k in a report on day t and the average private analysts' estimates $q_t^{k,P}$ that are released a few days prior:

(1)
$$Surprise_t^k = 100 \times \left(\ln q_t^{k,U} - \ln q_t^{k,P}\right).$$

If private expectations of USDA announcements are unbiased, positive and negative surprises should cancel out and average surprise should not be significantly different from zero. On the other hand, average absolute surprise reflects the average size of surprise regardless of sign. Figures 3 and 4 illustrate the patterns in average surprises and average absolute surprises for cattle and hogs, respectively. Figure 3 shows that cattle placements estimates had largest surprises throughout the study period while the magnitudes of surprise for cattle marketed and on feed estimates were much smaller. There is some consistency between placements and on feed surprises, i.e., large underestimations (positive surprises) in 1982, 1984, 1990, and 1999 in placements were also accompanied by overestimations (negative surprises) in marketings. There is no consistency in biases as years with large underestimations are typically followed by years

with overestimations. It appears that average surprises became closer to zero in 2000s. This pattern is also captured in absolute surprises that tend to become smaller in magnitude in 2000s across all three categories. Similar patterns are observed for the Hogs and Pigs reports in figure 4 with the size of surprise becoming smaller in 2000s. Differently from cattle, there appears to be a tendency to overestimate breeding inventory in the earlier part of the sample, which seems to be corrected in the later part of the sample.

Due to these apparent differences in surprise patterns revealed in these figures, we split our samples into pre-2000 and post-2000 sub-periods to analyze whether these patterns are statistically significant. Table 2 presents summary statistics of surprise variables in both Cattle on Feed and Hogs and Pigs reports including the results of test of bias in average surprises for pre- and post-2000 time periods. Our findings demonstrate a significant positive bias in the on feed surprises in Cattle on Feed reports suggesting that private analysts underestimated cattle inventories in the pre-2000 period. This bias is not present after 2000, indicating an improvement in private forecasts. While the placed surprises are not significantly different from zero, the variability in these surprises is much higher than that for any other category, as evident from figure 3. The correlation[9] between on feed and placed surprises grew from 0.78 to 0.82 between the earlier and later sub-periods, suggesting that surprises in placement estimates are being carried over into surprises in on feed estimates. A negative bias in the marketed surprise is observed during the pre-2000 period suggesting that the private analysts overestimated cattle marketings. Again, this bias disappears in the later sub-period as these private forecasts improve.

A similar pattern is observed in hog breeding surprise, with significant overestimation by private analysts in the early sub-period, which has been corrected in the later sub-sample. A different pattern is found in hog marketing surprise, with positive surprises persisting throughout the whole study period. However, due to higher variability, these positive surprises are not significantly different from zero in the pre-2000 period, but become significant in the post-2000 period when the variability reduces. Correlation[10] between hog breeding and marketing surprises decreased from 0.63 to 0.35 from the earlier to the later sub-period, suggesting an increasing separation in surprises between these two categories.

To assess changes in the size of market surprise and its variability over time, differences in average absolute surprises and differences in their variances across sub-periods are examined using a t-test with Welch adjustment and the Brown-Forsythe test, respectively.[11] Our findings in table 3 show that the means and variances for the two sub-samples are significantly different for each surprise category, dropping by 0.6 to 1.8 percentage points from the earlier to the later part of the sample. The largest change is observed in the most difficult category: the mean and standard deviation of cattle placement surprises decreased by 1.8 and 1.4 percentage points,

[9] Correlations are not shown in the table, but available from the authors upon request.
[10] Correlations are not shown in the table, but available from the authors upon request.
[11] Welch's (1947) adjustment of the t-test relaxes the assumption of equal variances across samples and can be used to compare means of sub-periods with unequal variances. The Brown-Forsythe test is based on the analysis of variance (ANOVA) of the absolute median differences; it is a modification of Levene's F-test which evaluates absolute mean differences in ANOVA and has been shown to perform better in terms of robustness and power in previous studies (e.g., Neter et al. 1996).

respectively, in the post-2000 period relative to the 1977-1999 period. The size of hog breeding surprise declined, on average, by 1.3 percentage points from 1982-1999 period to post-2000 period. All these findings of a downward movement in market surprises indicate either a possible improvement in the quality of private analysts' forecasts, or a decrease in the new informational content of USDA reports.

Changes in Price Reactions over Time

In efficient markets, asset prices reflect all publicly available information and instantly adjust to incorporate new information entering the market (Fama 1970). Thus, as prices would respond only to the unanticipated component of the new information, the main premise of the price reaction tests we perform is that the USDA reports have value for the market if futures prices change in response to their surprise component, whereas they have no value if futures prices do not change (Colling and Irwin 1990; Garcia et al. 1997).

To allow for time-varying volatility observed in futures prices, we specify the following GARCH system:

(2)
$$\Delta P_t = \mu + \sum_{k=1}^{K} \lambda^k Surprise_t^k + \gamma TrendDev_t + \sum_{p=1}^{P} \delta_p \Delta P_{t-p} + \varepsilon_t,$$
$$\varepsilon_t = \sigma_t z_t,$$
$$\sigma_t^2 = \omega + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2,$$

where $\Delta P_t = 100 \times (\ln P_t - \ln P_{t-1})$ is the percentage change in futures contract's settlement price from day $t-1$ to day t, ε_t is the regression error term, and z_t is a standard normal random variable. Futures contracts are subject to daily price limits from the previous day's settlement price, therefore they mask the true price reaction by making the free market equilibrium price no longer observable.[12] Livestock futures contracts, especially lean hogs, experienced several trading days that were subject to a limit hit in the past. Therefore, to measure the true price reaction to market surprises we compute the price difference from the day preceding the report release (if it was not subject to a limit hit) to the first non-limit move day (if the report-day was subject to a limit hit). The variable $Surprise_t^k$ is defined before as the percentage difference between the USDA's ($q_t^{k,U}$) and private analysts' forecasts ($q_t^{k,P}$) for category k in a report on day t, and takes the value of zero on non-report days.[13] The variable $TrendDev_t$ represents out-of-sample percent deviation of the USDA's estimate ($q_t^{k,U}$) from a 10-year rolling linear trend in inventories.[14] The lagged values of the dependent variable in the conditional mean equation are included to account for serial correlation in the daily futures price changes.

[12] The price limit for live cattle futures during our study period was 1.5 cents until 2004 and increased to 3 cents after 2014. The limit for lean hogs was 1.5 cents until1995, 2 cents during 1995-2006, and increased to 3 cents thereafter.

[13] The market surprise variable takes its corresponding value on the exact announcement day for reports released before or during trading hours, and on the following trading day for reports released after trading hours.

[14] The linear trend is estimated for each report month separately using the most recent 10 previous years. The number of cattle on feed and the total number of breeding and marketing hogs are used for live cattle and lean hogs,

Furthermore, in order to determine how to assess changes in price reaction to USDA livestock reports over time, we performed the structural break test developed by Bai and Perron (1998) by regressing the futures return series on an intercept and each of the surprise variable separately, allowing the surprise coefficient to vary across possible regimes. The Bai-Perron test is especially useful in the case of unknown and multiple break points. While we find no structural breaks in lean hog futures price responses, test results suggest that there are three structural breaks[15] in live cattle price reactions (July 17, 1989 and November 15, 1996 for on feed surprises, and December 2, 2003 for placement surprises). Therefore, we divide our sample into four sub-periods: R1=January 1, 1977-July 16, 1989, R2=July 17, 1989-November 14, 1996, R3=November 15, 1996-December 1, 2003, and R4=December 2, 2003-December 31, 2016 based on the results of the structural break test. The sub-period dummy variables are interacted with all the surprise variables in equation (2) to examine differences in price reaction across sub-periods. In addition, changes in price reaction over time are demonstrated by estimating equation (2) with a 10-year rolling window by dropping the earliest calendar year and adding the newest one as we move forward in time.

Table 4 shows the results in columns (I) obtained by estimating equation (2) for the full sample period. The columns (II) of table 4 show the results from equation (2) where surprise variables are interacted with the sub-period dummy variables, R1 through R4, to examine differences in price reaction across sub-periods.[16] While the results for different surprises are reported in separate columns for ease of presentation, the regression for live cattle includes all three surprises simultaneously, and the regression for lean hogs is estimated with both breeding and marketing surprises. Price reaction estimates that are statistically significant at the 10% level from rolling GARCH regressions are shown in figure 5.

Full sample results for live cattle show a negative reaction to placements surprise and a positive reaction to marketings surprise, and a lack of a significant reaction to on-feed surprise accompanied by a strong negative reaction in one of the sub-periods. Interpretation of these results has to take into account the informational content of these categories. Small and Mark (2007) provide an excellent guide to interpreting cattle on feed reports: cattle on feed values published in these reports reflect the inventory levels at a point in time (beginning of the month) and illustrate the levels of supply available in live cattle markets. Thus, all else equal, higher supply results in lower prices and higher than anticipated supply (positive surprise) will result in lower prices as well. Cattle placements reflect additions to cattle supply, therefore, larger placements result in lower prices and larger than expected placements (positive surprise) will result in lower prices as well. Cattle marketings, on the other hand, reflect reductions in supply, with higher marketings leading to higher prices and larger than expected marketings (positive surprise) resulting in higher prices as well. Therefore, the signs of the estimated coefficients are consistent with these expectations.

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respectively. Out-of-sample deviations from trend are then calculated as the difference between the USDA's figure in a given report and the forecast for that month obtained from the linear trend model.

[15] Potential break points are based on the sequential criteria at the 5% significance level.

[16] The length of autoregressive lags, p, is set to five for both commodities in all estimations. Their parameter estimates, δ_p, are not included in the table to save space, but available from the authors upon request.

The magnitude of estimated coefficient for cattle placements surprise is small (-0.041) but statistically significant for the entire sample; however it is insignificant in the first three sub-periods. A graph of the placements surprise coefficient estimated using rolling regressions shown in figure 5 shows lack of substantial changes over time.[17] This observation is confirmed by the Wald tests reported in the bottom of table 4 that examine statistical differences in the estimates across sub-periods and show lack of significant differences in market reaction to placements surprise over time.

The results for the full sample in table 4 indicate that when the USDA's cattle marketing estimates are 1% higher than expected, live cattle prices increase by about 0.102 percentage points. This reaction is the largest in the 1977-1989 sub-period (0.164), followed by the 1996-2003 sub-period (0.120), and the smallest reaction is observed during 1989-1996 (0.051). Wald test results at the bottom of the table suggest that there is significant difference between the first (1977-1989) and the second (1989-1996) sub-periods, as these are the highest and the lowest magnitudes of market reaction to this information. The pattern in live cattle market reaction to cattle marketing surprises shown in figure 5 is consistent with sub-period findings and shows a drop in market reaction after 1989, and an increase after 2002 until 2008, followed by no price reaction.

Figure 5 demonstrates that the magnitude of cattle price reaction to on-feed surprise increased dramatically during 1997-2007 and 2003-2012. This result is confirmed by the coefficient estimated for the 1996-2003 sub-period that suggests that a 1% increase in on-feed surprise results in 0.371 percentage point drop in live cattle futures prices. Based on the Wald test, the magnitude of this reaction is significantly different from the one observed in the second sub-period. Note that while cattle on feed inventories are probably the most important information in these reports, the absolute surprise levels are usually the smallest (especially in the post-2000 period) as inventories are largely determined by the previous months' values (starting on-feed inventories plus placements minus marketings), while the other categories contain new placements and marketings information. However, the deviation of cattle inventories from trend was 6.06 percent on average during the third sub-period, whereas it ranged from -0.42 to -4.24 percent in other sub-periods. Even though the coefficient on the trend deviation is statistically insignificant, it is possible that the increased market reaction during 1996-2003 could have been due to the abnormally high cattle inventories in the U.S. The pattern of cattle inventories relative to their trend is illustrated in figure 6.

In Hogs and Pigs reports, both breeding herd and market hogs describe current levels of different inventory categories. Small, Waterbury, and Mark (2007) discuss that "an increase in market hog inventory would indicate future increases in hog slaughter and pork supplies. This would cause prices to decrease, everything else held constant. … Market analysts can use the information in the report related to breeding herd inventory and average litter size to make long-term price forecasts based on expected expansions and contractions in pork production." (p. 2) Thus, a larger than expected inventory level (positive surprise) in either category would cause a drop in hog prices, but while changes in market hogs will have more immediate impacts, changes in breeding herd will have more impact on deferred futures contracts.

[17] The figure shows the estimated surprise coefficients that are statistically significant at the 10% level. In the case of insignificant estimates, the coefficients are plotted as zero.

Our results show the impacts of both hog inventory categories on nearby lean hog futures. Even though the Bai-Perron test results did not identify structural breaks, figure 5 demonstrates that market reaction to these reports has not been constant. Therefore, in addition to full period results, we present in table 4 the results for the sub-periods found in live cattle markets. Figure 5 suggests that market reaction to market hog inventory surprise increased through 2007 reaching -1.6 percentage points over 1998-2007 and decreased thereafter. The market reaction to hog breeding herd surprise exhibits a mirror-image to that of market hog surprise through 2005, but diminished thereafter. Results for the full period in table 4 suggest that an increase in breeding herd surprise of 1% results in a decrease of 0.485 percentage points in hog futures prices on average and an increase in a marketing hog surprise by 1% leads to a decrease of 0.514 percentage points. Furthermore, hog futures prices decrease by about 0.025 percentage points when hog inventories are 1% larger than their trend (larger supply than normal). The sub-period results indicate that the market reaction to breeding inventory surprise is significant only in the earlier part of the sample (1982-1996). Wald test results at the bottom of the table show that the price responses to breeding inventory surprises in the first and second sub-periods are statistically different from each other, as well as from other sub-periods. The sub-period findings for market hog surprises support the findings in figure 5 by showing an increasing price response over time with the strongest reaction during the 1996-2003 sub-period (-1.382) followed by a decline in magnitude during the most recent 2003-2016 sub-period (-0.597). Wald test results suggest that there are statistical differences between the price reactions over time. Only the equality of the price response to marketing hog surprises in the fourth sub-period (2003-2016) to the reaction in the first (1982-1989) and the second (199-1996) sub-periods is rejected, confirming the U-shape seen in figure 5.

Summary and Conclusions

This study investigates whether the impact of USDA's livestock reports, namely Cattle on Feed and Hogs and Pigs, has changed in the era of highly concentrated livestock markets. The analysis is built on the premise that forecasting capabilities of livestock firms would be enhanced by higher degree of market concentration as larger firms would have more resources to obtain and process data relative to smaller enterprises. In this case, their forecasts would improve relative to USDA's, resulting in a smaller difference between the two forecasts (i.e. market surprise) and smaller market price reaction to USDA information.

Our results indicate that in both cattle and hog markets there is evidence of strong price reaction to USDA reports until 2003 accompanied by evidence of smaller surprises in post-2000 years. While the markets still react to livestock surprises during 2003-2016, the impact on the price is smaller. Both of these findings point to better quality of private information that could have been caused by the rapid increase in vertical coordination in both livestock markets through consolidations and use of contractual agreements within the supply chain. The transition to higher degree of market concentration itself might have given these larger, more specialized firms much better access to information on current and expected livestock inventories than they used to have in the past. However, better private information does not erase the value of USDA reports as they continue to significantly affect both cattle and hog markets.

While we cannot contribute the findings observed in this study exclusively to higher market concentration, it has likely played a large role in improving private industry information in livestock markets. In this "thin market" environment, it is important for USDA to strengthen its efforts to provide high quality information for general public, in order to insure a plane level field for all market participants.

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Table 1. Maturities of Nearby Futures Contracts Used in Empirical Analyses

Calendar Month	Live Cattle	Lean Hogs
$January_t$	$February_t$	$February_t$
$February_t$	$April_t$	$April_t$
$March_t$	$April_t$	$April_t$
$April_t$	$June_t$	$June_t$
May_t	$June_t$	$June_t$
$June_t$	$August_t$	$July_t$
$July_t$	$August_t$	$August_t$
$August_t$	$October_t$	$October_t$
$September_t$	$October_t$	$October_t$
$October_t$	$December_t$	$December_t$
$November_t$	$December_t$	$December_t$
$December_t$	$February_{t+1}$	Feb_{t+1}

Note: The subscript, t or t + 1, refers to the year of the futures contract expiration date relative to the year t of the daily price being computed. May contract of lean hogs futures is eliminated due to low volume.

Table 2. Tests of Bias in Average Surprises for Pre-2000 and Post-2000 Sub-periods

Commodity/Category		Period	Mean	Std. Dev.	N	t-test	p-value	
Cattle								
	On Feed	1977-1999	0.33	1.63	250	3.15	0.00	***
		2000-2016	-0.02	0.81	204	-0.38	0.71	
		Full Sample	0.17	1.34	454	2.70	0.01	***
	Placed	1977-1999	0.55	6.14	250	1.42	0.16	
		2000-2016	0.12	3.88	204	0.45	0.65	
		Full Sample	0.36	5.25	454	1.46	0.14	
	Marketed	1977-1999	-0.33	2.99	250	-1.73	0.09	*
		2000-2016	0.02	1.49	204	0.15	0.88	
		Full Sample	-0.17	2.44	454	-1.51	0.13	
Hogs								
	Breeding	1982-1999	-0.74	2.36	72	-2.66	0.01	***
		2000-2016	0.00	0.78	68	-0.01	0.99	
		Full Sample	-0.38	1.81	140	-2.49	0.01	***
	Marketing	1982-1999	0.28	1.94	72	1.24	0.22	
		2000-2016	0.24	0.99	68	1.96	0.05	**
		Full Sample	0.26	1.55	140	1.99	0.05	**

Note: The t-test tests the statistical deviation of average surprise away from zero. The asterisks *, **, *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

Table 3. Tests for Equality of Absolute Surprises between Pre-2000 and Post-2000 Sub-periods

Commodity/Category			Full Sample	Pre-2000	Post-2000	Equality Test	p-value	
Cattle								
	On Feed	Mean	0.98	1.28	0.62	8.65	0.00	***
		Std. Dev.	0.92	1.06	0.52	41.07	0.00	***
		N	454	250	204			
	Placed	Mean	4.02	4.82	3.03	6.04	0.00	***
		Std. Dev.	3.39	3.84	2.42	20.61	0.00	***
		N	454	250	204			
	Marketed	Mean	1.79	2.35	1.10	9.11	0.00	***
		Std. Dev.	1.66	1.87	1.01	67.53	0.00	***
		N	454	250	204			
Hogs								
	Breeding	Mean	1.26	1.87	0.61	6.33	0.00	***
		Std. Dev.	1.35	1.61	0.47	28.20	0.00	***
		N	140	72	68			
	Marketing	Mean	1.18	1.50	0.85	4.05	0.00	***
		Std. Dev.	1.03	1.25	0.56	22.47	0.00	***
		N	140	72	68			

Note: The equality of means is tested by the t-test with Welch adjustment allowing for unequal variances across sub-periods. The equality of variances is tested by the Brown-Forsythe F-test. The asterisks *, **, *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

Table 4. Price Reaction Tests of the Informational Value of USDA Reports for Livestock

	Live Cattle Nearby Futures						Lean Hogs Nearby Futures			
	On Feed		Placed		Marketed		Breeding		Marketing	
	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)
Mean equation										
Surprise	0.010		-0.041 ***		0.102 ***		-0.485 ***		-0.514 ***	
	(0.058)		(0.014)		(0.016)		(0.047)		(0.052)	
$Surprise_{R1}$		0.010		-0.052		0.164 ***		-0.509 ***		-0.231 ***
		(0.133)		(0.032)		(0.042)		(0.085)		(0.081)
$Surprise_{R2}$		0.082		-0.020		0.051 ***		-0.811 ***		-0.640 ***
		(0.069)		(0.025)		(0.021)		(0.066)		(0.096)
$Surprise_{R3}$		-0.371 *		-0.008		0.120 ***		0.007		-1.382 ***
		(0.194)		(0.040)		(0.047)		(0.135)		(0.251)
$Surprise_{R4}$		-0.068		-0.072 *		0.105 *		-0.035		-0.597 ***
		(0.231)		(0.040)		(0.062)		(0.230)		(0.215)
Trend Deviation	0.000	0.002					-0.025 ***	-0.018 *		
	(0.004)	(0.005)					(0.008)	(0.009)		
Constant	0.019 **	0.018 **					0.005	0.005		
	(0.009)	(0.009)					(0.015)	(0.015)		
Variance equation										
ARCH	0.043 ***	0.043 ***					0.042 ***	0.042 ***		
	(0.003)	(0.003)					(0.003)	(0.004)		
GARCH	0.951 ***	0.952 ***					0.945 ***	0.946 ***		
	(0.003)	(0.003)					(0.005)	(0.005)		
Constant	0.005 ***	0.005 ***					0.025 ***	0.024 ***		
	(0.001)	(0.001)					(0.004)	(0.004)		
Hypotheses tests		Chi-squared [p-val]		Chi-squared [p-val]		Chi-squared [p-val]		Chi-squared [p-val]		Chi-squared [p-val]
H_0: $Surp_{R1}$=$Surp_{R2}$=$Surp_{R3}$=$Surp_{R4}$		5.00		1.93		6.71 *		37.65 ***		24.5 ***
		[0.17]		[0.59]		[0.08]		[0.00]		[0.00]
H_0: $Surp_{R1}$ = $Surp_{R2}$		0.23		0.59		5.71 **		7.68 ***		9.83 ***
		[0.63]		[0.44]		[0.02]		[0.01]		[0.00]
H_0: $Surp_{R1}$ = $Surp_{R3}$		2.65		0.75		0.5		10.35 ***		19.04 ***
		[0.10]		[0.39]		[0.48]		[0.00]		[0.00]
H_0: $Surp_{R1}$ = $Surp_{R4}$		0.09		0.15		0.63		3.76 **		2.54
		[0.77]		[0.69]		[0.43]		[0.05]		[0.11]
H_0: $Surp_{R2}$ = $Surp_{R3}$		4.83 **		0.07		1.80		29.85 ***		7.66 ***
		[0.03]		[0.79]		[0.18]		[0.00]		[0.01]
H_0: $Surp_{R2}$ = $Surp_{R4}$		0.38		1.18		0.68		10.52 ***		0.03
		[0.54]		[0.28]		[0.41]		[0.00]		[0.85]
H_0: $Surp_{R3}$ = $Surp_{R4}$		1.01		1.30		0.04		0.03		5.66 **
		[0.31]		[0.26]		[0.85]		[0.87]		[0.02]
Observations	10087	10087					8828	8828		
Log likelihood	-13247.00	-13226.52					-15285.22	-15268.62		
AIC	26520.01	26497.04					30594.44	30573.24		
BIC	26613.86	26655.86					30679.47	30700.78		

Note: Results are obtained by AR(5)-GARCH(1,1) estimation of equation (2). Values in ( ) are standard errors and values in [ ] are p-values. The asterisks *, **, *** represent statistical significance at the 10%, 5%, and 1% level, respectively. Full sample period is 1977-2016 for live cattle and 1982-2016 for lean hogs. The subscripts R1, R2, R2, and R4 stand for regime sub-periods determined by structural break tests, where R1=January 1, 1977-July 16, 1989; R2= July 17, 1989-November 14, 1996; R3=November 15, 1996-December 1, 2003; and R4=December 2, 2003-December 31, 2016.

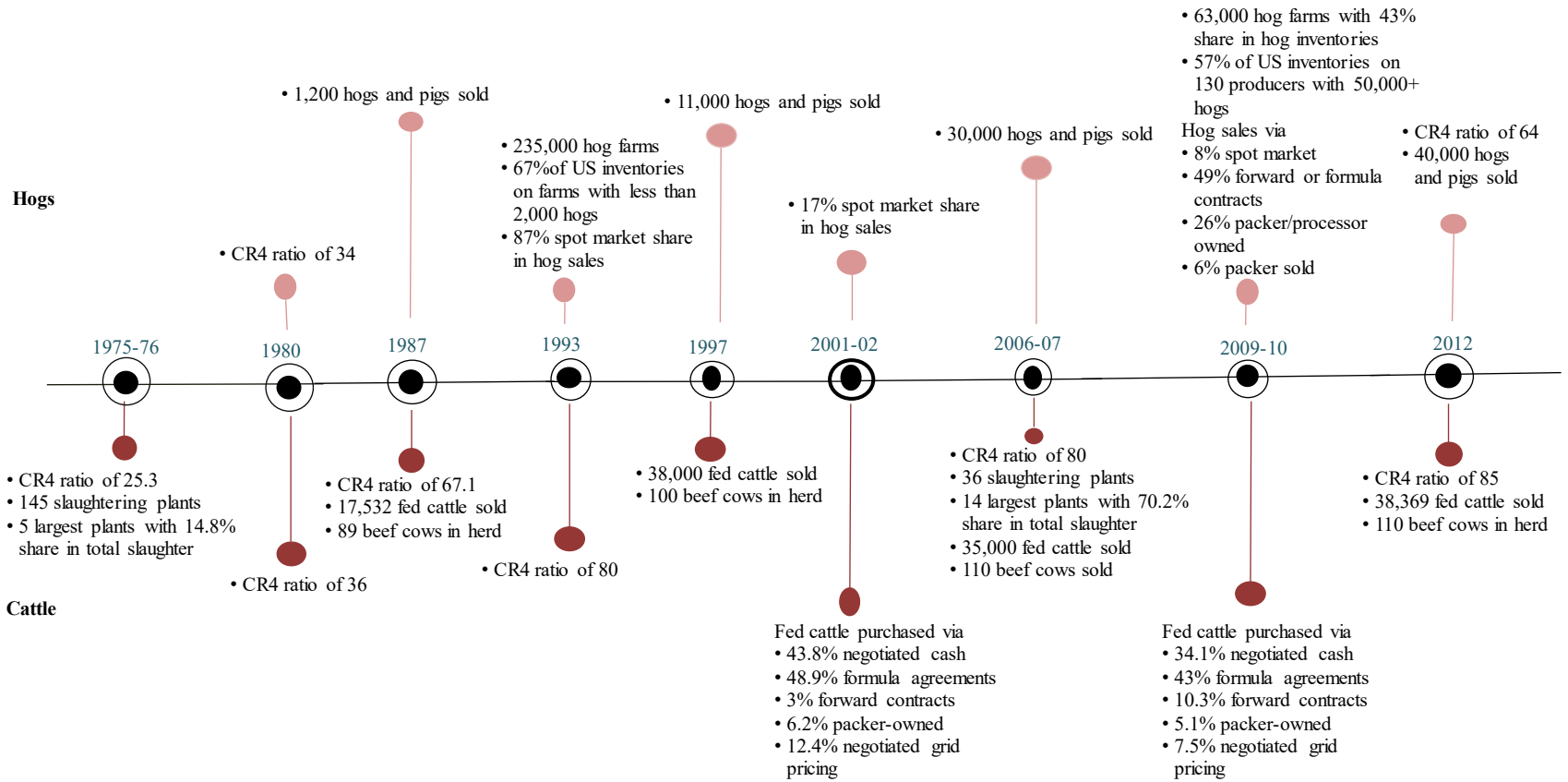

Figure 1. Structural changes in livestock markets

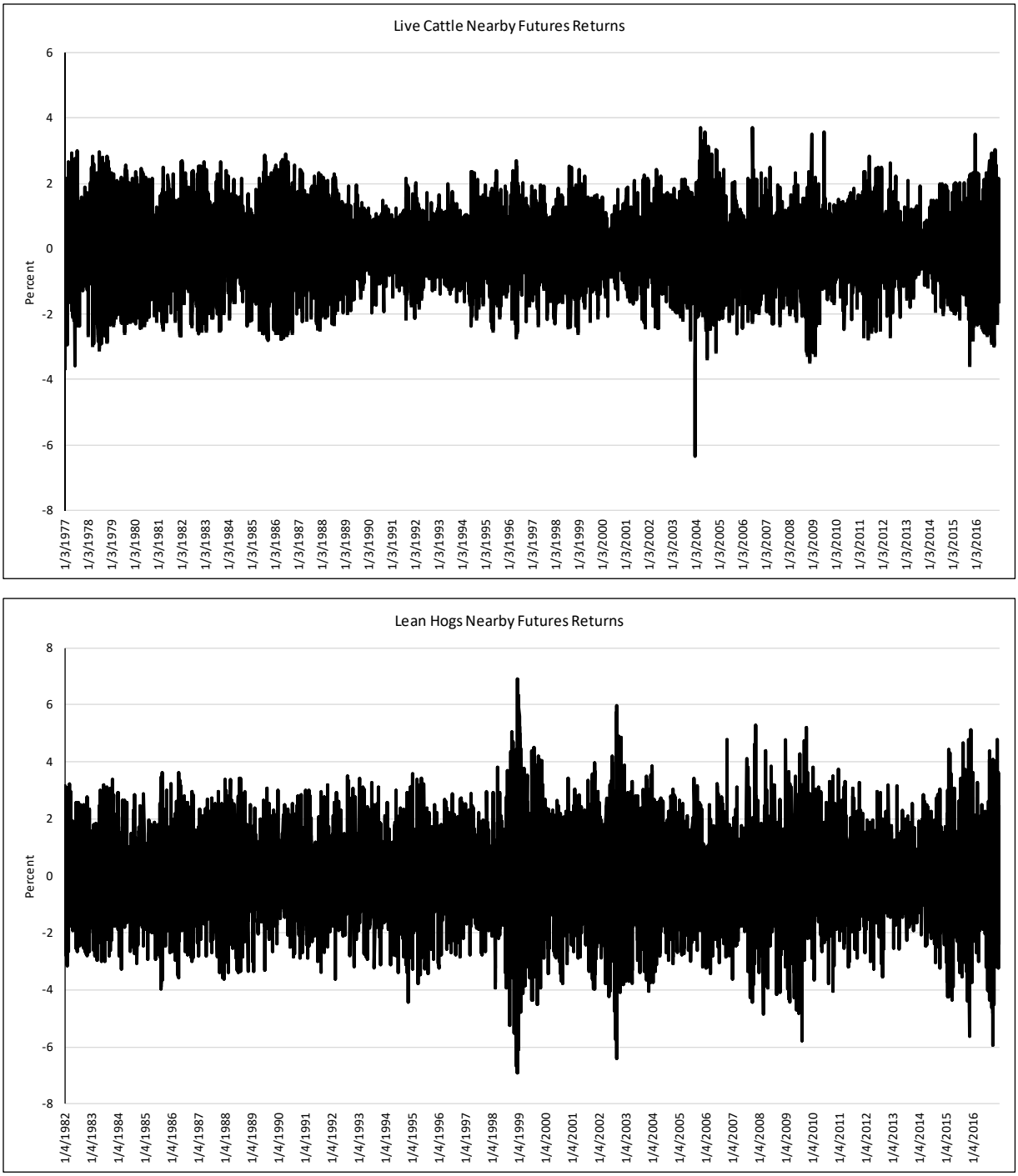

Figure 2. Live cattle and lean hogs nearby futures returns

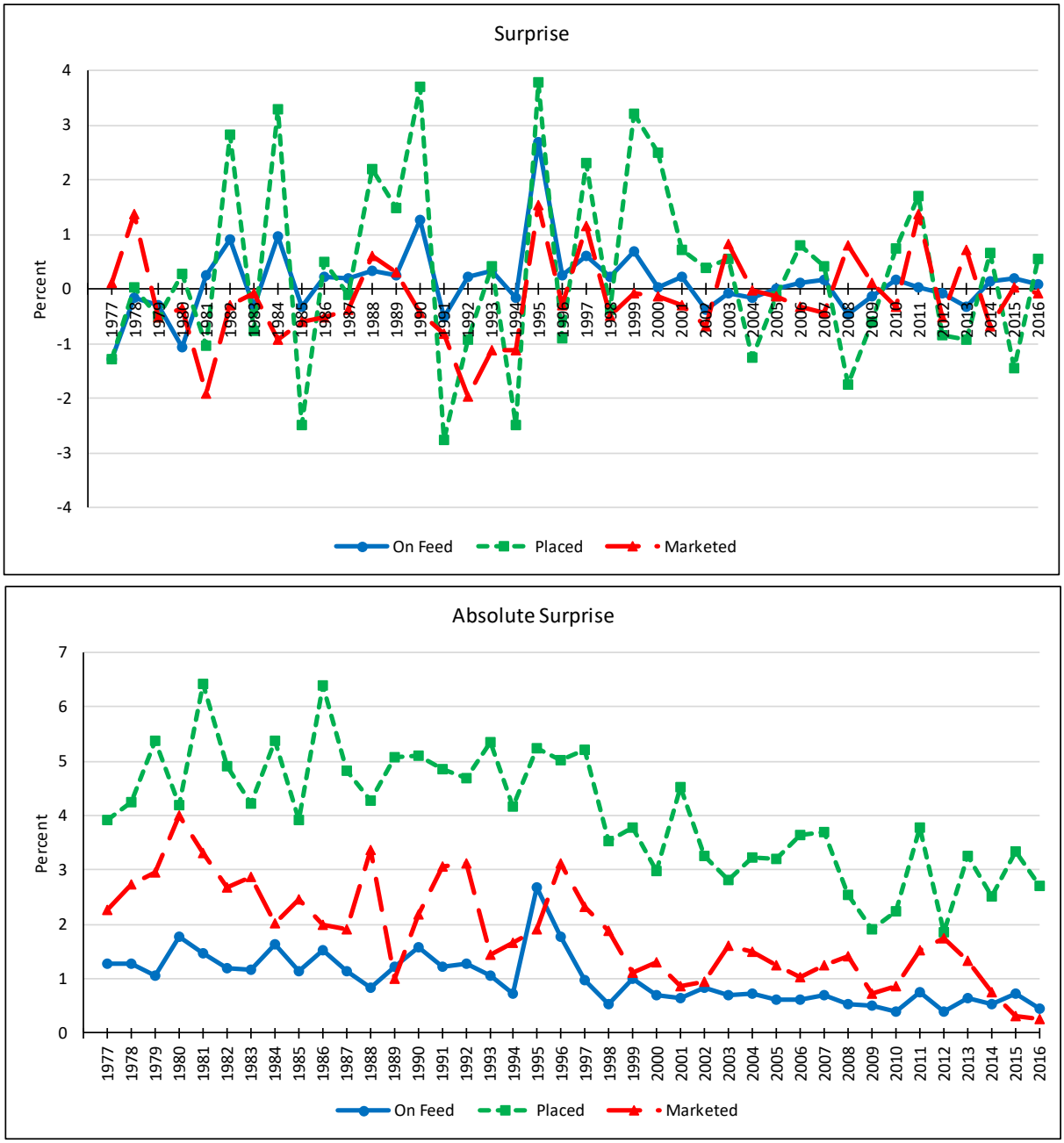

Figure 3. Average annual market surprises in Cattle on Feed reports

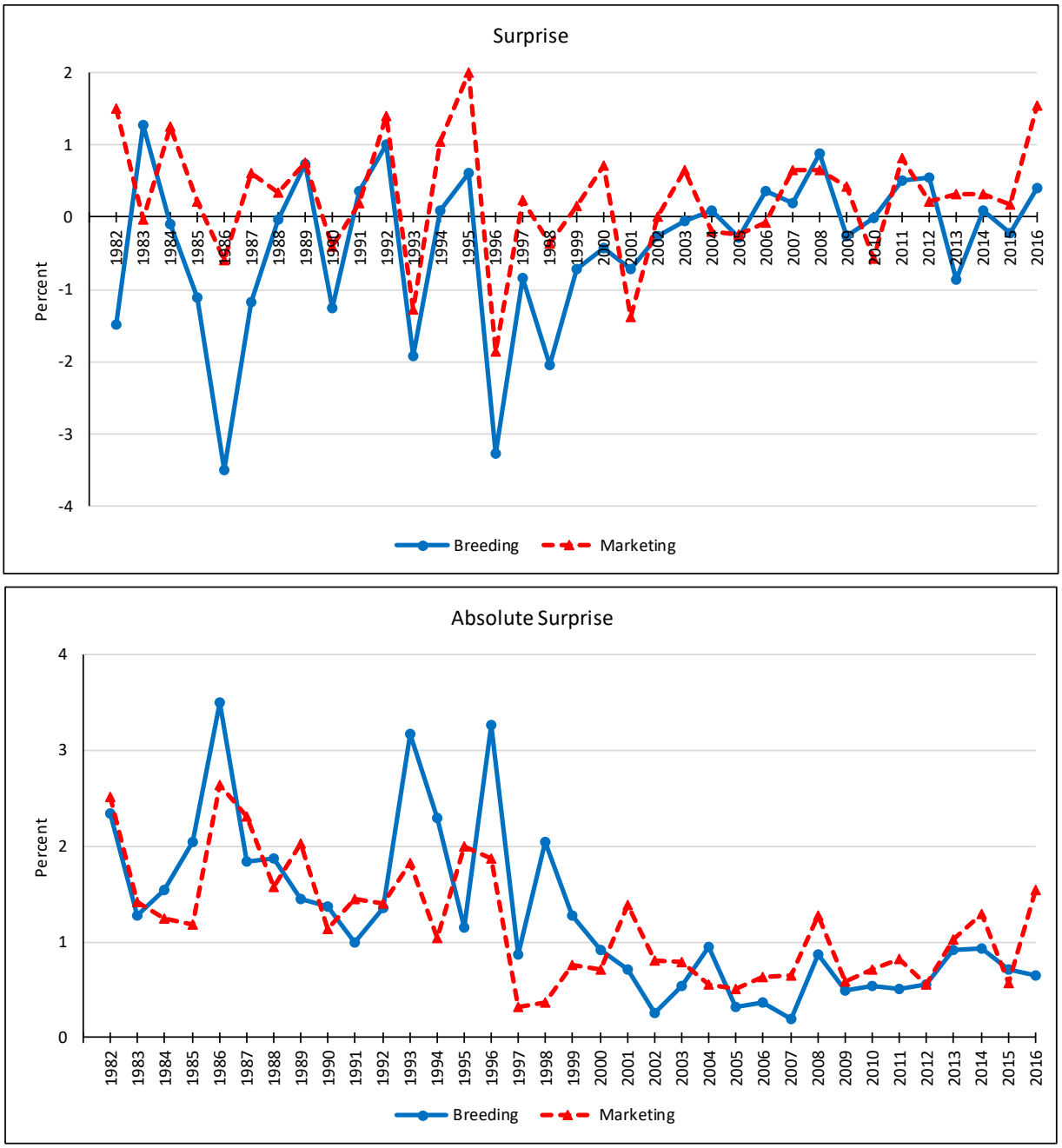

Figure 4. Average annual market surprises in Hogs and Pigs reports

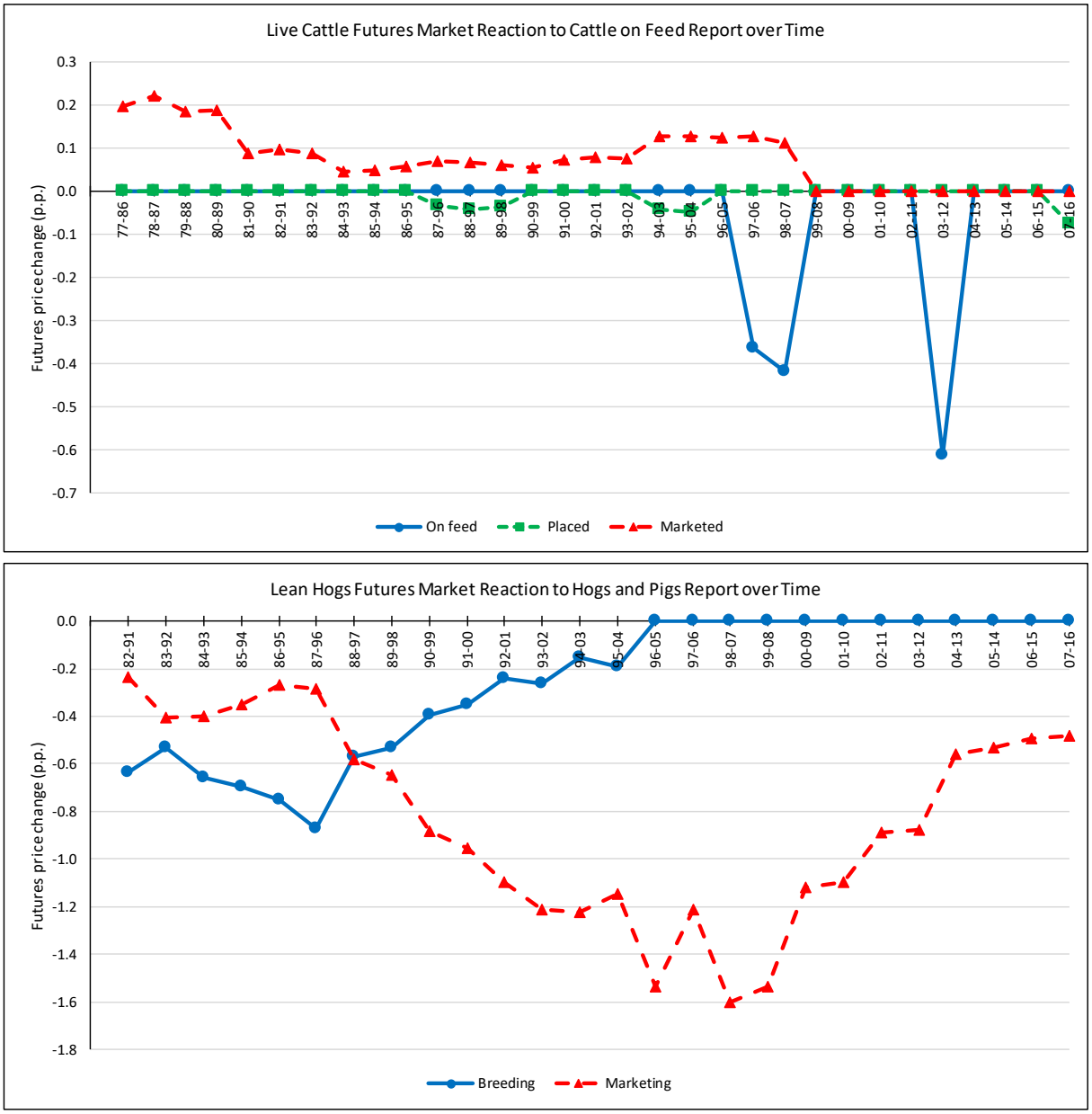

Figure 5. Livestock futures market reactions to USDA reports over time (at the 10% significance level)

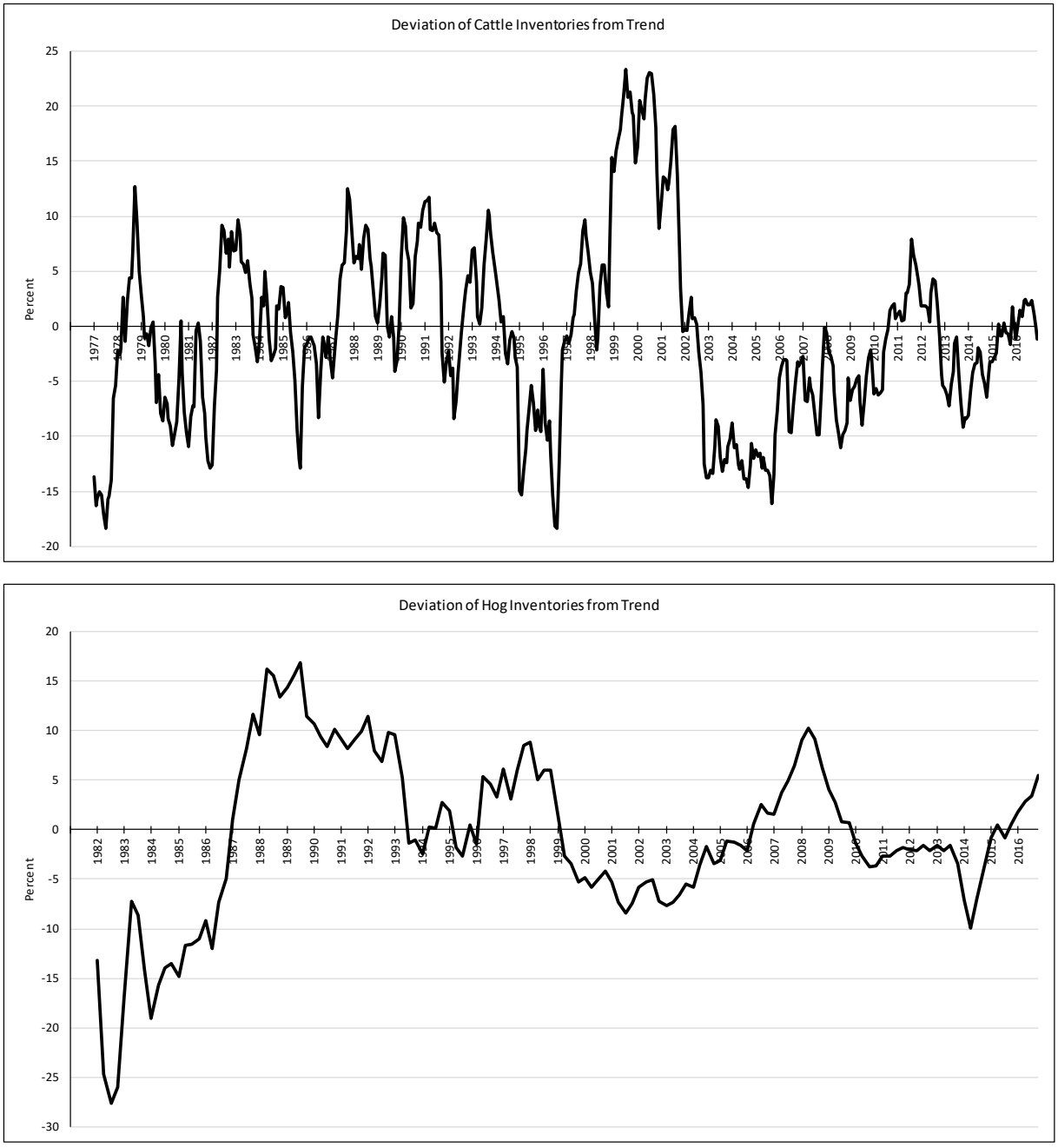

Figure 6. Livestock inventory deviations from trend