Price Determination and Price Discovery in the Fed Cattle Market: A Review of Economic Concepts and Empirical Work

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Abstract

Price discovery and price determination are closely related but distinct economic concepts related to the efficient and effective performance of markets. In discussions regarding the performance of prices in the fed cattle market, these two concepts are frequently not adequately distinguished. This leads to confusion regarding the perceived problems in the market and, consequently, potentially effective solutions. This paper will describe both price discovery and price determination, focusing on the factors that influence the price discovery process in the fed cattle market. To assess the state of price discovery in regional fed cattle markets, an event study is performed using the reaction of regional cash fed cattle prices to unanticipated information in monthly *Cattle on Feed* reports. Results suggest that, while the information content of negotiated prices by region has changed in recent years, all regions continue to contribute meaningful to price discovery in the overall market. This result calls into question the need for proposed policy interventions to improve price discovery, as does the potential for such interventions to impede the ongoing market-driven evolution of pricing institutions in the sector.

Few issues in the agricultural economy have attracted as much attention for as long a time as the behavior of prices in the fed cattle market. Questions about the accuracy and volatility of livestock prices – and particularly about the relationship of market structure to those issues – have been thoroughly investigated and hotly contested for well over a century now – with, it seems, little prospect for resolution even now.

A brief example from history should suffice to illustrate the impressive continuity between past and present controversies in the livestock and meat sector. In summarizing the results of a major congressionally-mandated investigation into meat-packer business practices by USDA and the Federal Trade Commission (FTC) in the early twentieth century, Virtue (1920) notes that

> One of the most general and persistent complaints of the feeders is that prices of livestock so frequently have no relation to cost of production, and, taken for short periods, no relation to natural market conditions; that these fluctuations introduce so great an element of risk as to make feeding one of the most hazardous of industries, resulting in disastrous losses to the feeders and in the end throwing a great burden on consumers as well. Well-informed stock men are convinced that these erratic price movements can be explained only on the theory of "manipulation" by packers, whom they regard as the beneficiaries of the changes. (p. 652)

The issues that concerned Virtue's "well-informed stock men" related to whether or not livestock prices accurately reflected underlying supply and demand conditions, how quickly those prices adjusted to new information, and whether or not the concentration of market power at the processing level led to intentional, strategic manipulation of these processes. This would be a pretty fair summary of the concerns of today's cattle market participants as well. In slightly more technical jargon, these are issues that touch on the distinct but related concepts of price determination and price discovery.

Definition of Terms

The terms "price determination" and "price discovery" are used virtually interchangeably in a great deal of non-technical communication about markets. However, among agricultural economists, these are terms of art with specific meaning, referring to different but related concepts relevant to any discussion of commodity pricing. In order to productively assess the impacts of changing institutional arrangements in the fed cattle market on price behavior, it is helpful to clearly distinguish between these concepts.

Price determination refers to how the forces of supply and demand for a particular product or commodity interact to produce an equilibrium price. It is concerned not with the outcome of any particular transaction but rather with the general price level that prevails based on fundamental conditions in the broader market. Price determination is well-represented graphically by the classic, "Marshallian scissors" supply and demand graph, as depicted in Figure 1.[1] The interaction of market supply and market demand – reflecting the summation of individual participants on each side of the market – results in an equilibrium price and quantity.

In contrast to price determination, price discovery refers to the means by which a particular buyer and seller arrive at a price on a specific transaction. In reality, market supply and demand are not directly observable. Buyers and sellers lack perfect information, so the equilibrium price and quantity are not as readily transparent as Figure 1 might imply. Thus bid (buyer) and ask (seller) prices will vary around the equilibrium price in the process of price discovery. This process is illustrated in Figure 2, in which the "true" supply and demand are bracketed by the upper and lower estimates of market participants. Bid and ask prices would be

[1] The graphical representations of price discovery and price determination in figures 1 and 2 are common depictions of a market. In the context of specifically illustrating price determination and price discovery, though, these graphs borrow directly from Ward and Schroeder (2004).

expected to fall between the high and low prices implied by the intersection of these supply and demand estimates, centering around the true equilibrium price.

Price discovery is concerned directly with the mechanics by which individual transaction prices (and other terms of trade) are established rather than with broader, and generally more theoretical, issues of how supply and demand fundamentals affect the general price level (Tomek and Kaiser 2014). In effect, then, price determination represents a macro-level perspective on the equilibrium price while price discovery represents a micro-level perspective on the variability of prices around that equilibrium.

With these distinctions in mind, it is worth noting clearly what improving price discovery can and cannot do. Most importantly, improving price discovery cannot be expected to improve the overall level of prices if prevailing supply and demand fundamentals are consistent with low prices. That is, if supply and demand conditions in the market are consistent with low prices (price determination), then the interactions of buyers and sellers in specific transactions should produce a low average price (price discovery). Realistically, what improving price discovery can accomplish is to make prices more efficient.

Efficiency is another term that has a specific meaning among economists. A market is efficient if prices in that market reflect all available information (Fama, 1970). Janzen and Adjemian (2017) note that effective price discovery accomplishes the task of reflecting underlying information in a timely manner and does so via "bona fide transactions or standing bids and offers whose prices are known to all market participants" (p. 1192). This understanding of price discovery offers a useful perspective in that it allows potential price discovery issues to be separated from mere discontent over price determination at a low price point. For example, are market transactions truly bona fide? In a heavily concentrated market where power between

buyers and sellers is dramatically asymmetrical, are transactions a reliable reflection of underlying fundamental conditions or are they distorted by the impact of that power asymmetry on the negotiation process? Further, as the volume of transactions declines, are there sufficient transactions or open bids to inform the broader market? In other words, how many negotiated transactions are needed to adequately reflect underlying fundamental information? These and similar issues complicate the conceptually simple relationship between price discovery and price determination.

Complicating Factors: Market Concentration

The meatpacking sector is, and has long been, highly concentrated. The most recent annual report from USDA Agricultural Marketing Service, Packers and Stockyards Division (2020) puts the four-firm concentration ratio for the steer and heifer processing sector at 85%, consistent with the level of concentration since the 1980s. Concentration ratios in regionally-defined markets are generally even higher (Ward, 1988). This high degree of market concentration has long fostered concern that prices are manipulated through non-competitive behavior (e.g., see the earlier citation from Virtue, 1920). A great deal of work over many years has sought evidence of such behavior in the fed cattle market, but such work has consistently found little support for significant negative price effects of concentration (Ward, 1997; Ward, 1999; Crespi, Saitone, and Sexton, 2012).

Even aside from the intentional exercise of market power, concentration could have more subtle effects on price discovery. Concentration in the meatpacking industry has largely been driven by the significant economies of size associated with meatpacking operations (Ward, 1988). Bailey and Brorsen (1987) note that economies of size could directly influence price discovery. Larger firms have more total information (public plus private) simply by virtue of the

volume of transactions to which they are party. If this combination of information is more accurate than public information alone, price discovery may be affected. Price adjustments to new information in concentrated markets may also be affected if one or two major firms play a price leadership role (Goodwin and Holt, 1999).

Complicating Factors: Thin Market Issues

A market in which negotiated transactions over a given period of time are not sufficient to support efficient price discovery is a thin market (Anderson et al., 2007). In a thin market, prices may become a less reliable guide to actual value as supported by market fundamentals and, in so doing, contribute to resource misallocation (Adjemian, Saitone, and Sexton 2016). In a practical sense, in such a market, we would expect to see increasing variability of prices around the equilibrium price; and evaluations of price discovery on thin markets often involve some means of quantifying this phenomenon (Tomek 1980).

There is no doubt that pricing behavior in the fed cattle market has changed dramatically, particularly within the past decade, in ways that raise concerns about effective price discovery. While the total number of cattle traded each week remains quite large, negotiated transactions as a percentage of all transactions have fallen sharply. This is illustrated in figure 3, which shows the percentage of total weekly fed cattle transactions accounted for by each transaction type reported by USDA Agricultural Marketing Service from January 2009 through March 2021. The change in the proportion of negotiated cash transactions is significant. For example, in 2010, 45 percent of all fed cattle transactions were negotiated (either negotiated cash or negotiated grid); 39 percent were formula-based transactions. In 2020, just 26 percent of fed cattle transactions were negotiated while 63 percent were formula-based.

The decline in negotiated transactions is more pronounced at the regional level. For example, in the southern Plains feeding region, the volume of negotiated transactions has become quite small in recent years. This is confirmed by figure 4, which shows negotiated cash and formula-based fed cattle transactions in Texas/Oklahoma from January 2009 through March 2021. For the whole of 2020, negotiated cash transactions in this region amounted to just 12% of formula-based transactions.

To a large extent, formula-based transactions rely on some previous negotiated price as a key component of the pricing formula (Coffey, Pendell, and Tonsor, 2019). Thus, more and more formula transactions are dependent on negotiated prices that reflect fewer and fewer underlying sales. As Adjemian et al. (2016) point out, this has the potential to propagate any pricing inefficiencies more broadly, thus magnifying any pricing problems that already exist. This is not a new concern. Schroeder et al. (1998) report results of a survey of both feeders and packers regarding fed cattle pricing practices. Those survey respondents note the potential for quality differences between negotiated and formula sales to result in pricing inaccuracies. Livestock Mandatory Price Reporting (LMPR) was intended to alleviate at least some of these concerns. For example, LMPR made it impossible for packers to manipulate the base price in formulas by only reporting some of their negotiated prices (Matthews et al., 2015). However, as the negotiated side of the market has thinned further, concerns over pricing accuracy related to formula pricing have intensified.

While many researchers have acknowledged the thinness of the negotiated fed cattle market and the potential for price discovery problems which that implies, considerable empirical work with data available through LMPR has yet to document significant problems (Crespi, Saitone, and Sexton, 2012; Brorsen, Fain, and Maples, 2018). In a deep-dive into livestock

pricing practices initiated by congressional action and making use of a unique data set on individual transactions compiled by USDA Grain Inspection, Packers and Stockyards Administration, Muth et al. (2007) found small negative price effects from the use of alternative marketing arrangements (AMAs, which include formula pricing). However, they also documented significant cost savings and quality improvements facilitated by AMAs – benefits that far outweighed the small negative price effects, such that eliminating AMAs would reduce both producer and consumer surplus in the sector. In a more recent study, Ward, Vestal, and Lee (2014) found that the relationship between negotiated and formula prices remained remarkably stable even as negotiated transaction volume declined. Thus, while negotiated transactions in the fed cattle market have clearly thinned, dramatically so in some regions, there is little objective evidence that this has adversely affected price discovery generally or that it has compromised the functioning of formula arrangements tied to negotiated prices.

The inability of researchers to document thin-market-related pricing problems in the fed cattle sector is not too surprising for two primary reasons. First, defining the point at which a market becomes "too thin" is notoriously difficult (Adammer, Bohl, and Gross, 2016). Previous work on thinning markets shows that relatively few transactions are required to maintain pricing efficiency as long as negotiated transactions are representative of the market as a whole (Tomek, 1980). Second, due to significant economies of size in packing plants, packers have a strong incentive to offer reasonably fair pricing terms in order to ensure optimal throughput for their plants over a long time horizon (Morrison Paul, 2001; Anderson, Trapp, and Fleming, 2003; MacDonald and Ollinger, 2005; Crespi, Saitone, and Sexton, 2012).

Fed Cattle Price Discovery: An Event-Study Evaluation of Market Efficiency

A natural question to ask, in light of the increased use of formula pricing and associated concern over the effectiveness of price discovery in an increasingly thin negotiated market is which, if any, of the major LMPR regional markets best reflect market supply and demand fundamentals in their negotiated prices? We seek to shed light on this issue using an event study approach to measure price responses to unanticipated information contained in monthly USDA *Cattle on Feed* (*COF*) Reports. The objective of this event study is to determine whether the efficiency of price discovery has been affected by changes in fed cattle pricing practices. Specific objectives are twofold: 1) to determine whether the process of price discovery has changed over time as pricing practices have evolved and 2) to identify any differences in the efficiency of price discovery across regions correlated with regional changes in fed cattle pricing practices.

The issue of cattle market price discovery has drawn much attention in the literature, and a recent study by Coffey, Pendell and Tonsor (2019) found that the role played by the various LMPR cash market regions has changed over the years. In particular, they highlighted the growing importance of Colorado as the share of negotiated transactions taking place in more traditional regions – e.g., Texas/Oklahoma/New Mexico – has decreased.

A large literature has shown that grain and livestock market futures prices respond to unanticipated information contained in USDA reports (Grunewald, McNulty, and Biere, 1993; Adjemian, 2012; Garcia et al., 1997; Isengildina-Massa et al., 2008a; Isengildina-Massa et al., 2008b; McKenzie, 2008; Sumner and Mueller, 1989; Karali, Isengildina-Massa, and Irwin, 2019). The unanticipated component of the report, which may be thought of as a market shock, is typically measured as the difference between analyst forecasts of the report and actual report numbers officially released by USDA. Thus, if it can be assumed that USDA reports contain valuable information, then significant price responses that are consistent with that information

are indicative of price discovery. With this in mind, we examine the response of the five major LMPR regional negotiated cash markets (i.e., Colorado, Iowa/Minnesota, Kansas, Nebraska, and Texas/Oklahoma/New Mexico) to the release of unanticipated information about on-feed inventory, placements, and marketings, contained in *COF* reports. By isolating specific supply and demand shocks, this approach allows us to examine the extent to which market prices respond in a rational manner consistent with effective price discovery. Larger than anticipated increases in on-feed inventory and placements – which reflect higher cattle supply – should elicit price decreases. Conversely, larger than anticipated increases in cattle marketings -- which reflect both increased demand and expectations for smaller remaining short-run supply – should result in price increases.

Each component of the *COF* report provides the market with information that is used to make inferences about current and future beef production. On-feed inventory and marketing more closely relate to near term production, and shocks would be expected to have impacts on current cash market prices or nearby futures contract prices. On the other hand, surprises to cattle placements which have implications for future beef production, affect supplies in future months, should influence deferred live cattle futures contract prices and cash prices several months after the *COF* report release date. However, the exact timing of price impacts with respect to surprises in placements is somewhat ambiguous depending upon cattle weights and is ultimately an empirical question. For example, nearby live cattle futures prices and current cash prices could be impacted through a feedback effect whereby the expectation of future price decreases could increase current supplies and depress current cash prices.

Grunewald, McNulty and Biere (1993) found that surprises to both placements and marketings moved deferred live cattle futures prices, but that only surprises to marketings

affected nearby futures prices. Specifically, when placements are one percent higher than expected, this results in a 0.07 – 0.09 percent decrease in deferred futures prices; and when marketings are one percent higher than expected, deferred futures prices increase by 0.15 – 0.18 percent. In contrast, Karali, Isengildina-Massa, and Irwin (2019) showed that surprises to both placements and marketings affected nearby live cattle futures prices prior to 2000, while only shocks to marketings impacted nearby futures prices after 2000. Their results are similar to Grunewald, McNulty and Biere. For example, when placements are one percent higher than expected nearby futures prices, prior to 2000, decrease by 0.04 percent, and when marketings are one percent higher than expected nearby futures prices increase by about 0.1 percent over 1977 – 2016 period.

Data

Monthly livestock market analyst forecasts reported in the *Cattle Buyers Weekly* newsletter and USDA announcements of monthly on-feed inventory, placements and marketings contained in *COF* reports were collected over the January 2004 – December 2020 period.[2] Each month, between four to eight analysts make projections, which are reported in *Cattle Buyers Weekly* on the Monday prior to a Friday's *COF* release date. The average trade estimate is taken to be the median analyst forecast. USDA numbers and analyst forecasts are reported for the current month as a percentage of the comparable month a year ago. Market surprises, or the unanticipated component of the reports, were then measured as the percentage difference between the USDA

[2] *Cattle Buyers Weekly*, on occasion, did not publish a monthly preview due to a publishing break or business travel. Over the sample period, this occurred twelve times (September 18, 2017, January 18, 2016, December 14, 2015, July 16, 2012, February 15, 2010, April 13, 2009, September 15, 2008, October 16, 2006, January 16, 2006, September 19, 2005, October 18, 2004, and February 16, 2004).

numbers and the median analyst forecasts for on-feed inventory, placements, and marketings with respect to each monthly report over the sample period.

In addition, weekly weighted average of live steer and heifer cash prices of the five major LMPR regions (Colorado, Iowa/Minnesota, Kansas, Nebraska and Texas/Oklahoma/New Mexico) were collected over the same January 2004 – December 2020 period. *COF* reports are typically released on Friday afternoons each month at 2:00 pm central time.[3] To measure LMPR region cash price responses to market surprises in on-feed inventory, placements, and marketings, prices for the immediate week prior to a *COF* report release and for the immediate week following a *COF* report release were logged and the percentage change in price around each of the *COF* report months calculated.[4]

Methods

A typical event study model can be written as an Ordinary Least Squares (OLS) regression:

1) $$P_{+1} - P_{-1} = \tilde{a} + \tilde{b}\left(COF_{ijt}^{USDA} - COF_{ijt}^{Private}\right) + e_t,$$

where in our study, $P_{+1} - P_{-1}$ represents the logged percentage change in the negotiated cash fed cattle price from the week prior to the report release to the week following the report release. The term, $(COF_{ijt}^{USDA} - COF_{ijt}^{Private})$ represents the surprise or shock element of *COF* reports, where COF_{ijt}^{USDA} represents the USDA forecast of either on-feed inventory, placements or marketings related information i, observed in month j and year t, and $COF_{ijt}^{Private}$ represents the

[3] There were 4 missing observations for the Texas/Oklahoma/New Mexico series and 26 missing observations for the Colorado series because no prices were reported in those regions in certain weeks. The Colorado missing observations occurred between May 2018 and December 2020.

[4] It should be noted that the immediate week prior to a *COF* release is actually the 5 days Monday – Friday of the *COF* release week. Given that, *COF* reports are released on Friday afternoons at 2pm central time, a small percentage of the week's LMPR recorded prices may have occurred after the *COF* release.

median livestock market consensus forecast of either on-feed inventory, placements, or marketings related information i, observed in month j and year t. And e_t is a mean zero normally distributed error with constant variance. term.

In the traditional event study approach, the estimated regression coefficient $\tilde{b}$ measures the average price response to a one-percentage point change in the surprise element of USDA reports. Thus, it is assumed that LMPR cash prices only react to the element of *COF* report information that was not anticipated by the analysts and the private sector livestock industry. While we assume that rational LMPR cash price reactions to *COF* surprises are indicative of price discovery, we acknowledge that these cash prices are also likely influenced by other market conditions and are likely noisy estimates of price discovery.

We present several different event study results based on equation (1) regressions of cash price changes on *COF* market surprises. First, we analyze our model using data from the full sample period, January 2004 – December 2020. Second, we analyze our model including only observations where placement surprises and marketings surprises would be expected to induce price reactions in the same direction. Our objective is to remove *COF* surprises associated with noisy price signals and only analyze the price impact of consistent, unambiguous bull or bear market surprises. Given that, *a priori*, we would expect price responses to be negatively correlated to placement surprises and positively correlated to marketings surprises, our goal is to remove monthly observations with either (a) larger than expected placements and larger than expected marketings, or (b) lower than expected placements and lower than expected marketings. Specifically, we only retain observations for months when positive placement surprises are simultaneously observed with negative marketings surprises (bear market shocks) and negative placement surprises are simultaneously observed with positive marketings surprises (bull market

shocks). Third, and again to measure price discovery with respect to clear signals, we retain only observations with large placements (3% or larger in absolute terms) and/or marketings surprises (1% or larger in absolute terms) within our second (consistent bull or bear shock) data category.

In addition, and to make a fairer comparison between LMPR markets, the second, third and fourth applications of our analysis only include months where there are no missing observations across all five reporting regions. Finally, using our second (consistent bull or bear shock) data category, we split the sample between January 2004 – December 2013 and January 2014 – December 2020. Our objective in this case is to examine if the primary LMPR cash market price discovery locations change over time. Our motivation stems from the fact that since 2014, the percentage volume of negotiated cash transactions occurring in the Texas/Oklahoma/New Mexico region has decreased dramatically. Prior to 2014, this region accounted for 20% to 40% of negotiated transactions, with the number decreasing consistently over the period (Coffey, Pendell and Tonsor, 2019). However, in the post-2014 period this number had dropped to around 10% of negotiated transactions, which begs the question as to whether the price discovery role played by this market has also diminished over time.

Results

The size of market surprises for on-feed inventory, placements, and marketings is illustrated graphically in figure 5. Clearly, the magnitude of these surprises has remained constant over time, suggesting that the price discovery role played by *COF* reports has likely not diminished. Surprises to placements are typically much larger than either marketings or on-feed inventory surprises, with the latter by far the smallest. In addition, there does not appear to be any systematic bias in analyst forecasts with over-estimates equally as likely as under-estimates.

Correlations between market surprises and LMR cash price changes around the *COF* report releases for our whole January 2004 – December 2020 sample period are presented in table 1 and highlight several important implications of the data. First, on-feed inventory and placement surprises are highly positively correlated (0.81), such that including both as explanatory variables in a regression would likely lead to problems of multicollinearity. With this is mind, and given that preliminary specifications indicated that on-feed inventory surprises were insignificant and added no explanatory power beyond placement surprises, we present models and results with on-feed inventory surprises excluded. Second, as expected, on-feed inventory and placement surprises are negatively correlated to marketings. Larger than expected on-feed inventory and placement numbers, which correspond to higher supply, tend to occur when marketings, which are associated with lower supply and higher demand, are lower than expected. Third and consistent with economic theory, on-feed inventory and placement surprises – supply side shocks – are negatively correlated to LMPR cash price changes, while marketings surprises – demand side shocks – are positively correlated to LMPR cash price changes. Fourth, cash price changes across all five LMPR market regions are highly positively correlated ($\rho >$ 0.9), suggesting that these markets are well integrated and that price discovery signals are quickly transmitted.

Regression results based on equation (1), which measure immediate LMPR cash price responses to *COF* surprises for the full sample period, are reported in Table 2. Results show, that although all cash price responses are of the expected signs, only Kansas prices have a small but significant response to placement surprises. A 1% larger than expected increase in placements results in a 0.076% decrease in Kansas prices, which is roughly in line with previous research measuring cattle futures price reactions (Grunewald, McNulty and Biere ,1993; Karali,

Isengildina-Massa, and Irwin, 2019). Also, R-squared values of around 2% show that *COF* surprises explain little of the price variation across LMPR markets. If anything, *COF* reports on average provide very noisy price signals.

Consistent Bull and Bear Market Pricing Signals

Turning to results for our models designed to measure clearer bull and bear market pricing signals, we can see much stronger correlations between LMPR cash prices for all regions and *COF* surprises in table 3. However, a natural and expected effect of organizing our data in this manner is to induce a high degree of correlation (ρ = -0.67) between placements and marketings. As such, our regression models based on this data will suffer from muticollinearity between placements and marketings. It should be noted that the consequences of mulitcollinearity is to reduce the precision or accuracy of our coefficient estimates and increase their standard errors, reducing our ability to detect significant effects in our multiple regression models. However, importantly, the predictive and explanatory power of such models in terms of R-squared values is not diminished, and the joint contribution of our explanatory variables (placement and marketings surprises) can be still be measured. Therefore, in the top half of table 4 we present our consistent Bull or Bear market surprise models results for our multiple regression specifications (with both placement and marketings surprises included as explanatory variables), and for comparison purposes we present regression results for placement and marketing surprises modeled separately as explanatory variables.

Although, as expected, coefficients are not significant for our multiple regressions, the R-squared values are much higher in comparison to our full sample results presented in table 2. The Texas/Oklahoma/New Mexico and Kansas markets appear to best incorporate the *COF* information with around 10% of the weekly price variation following the report release dates

explained by surprises to placements and marketings. In contrast, only 5% of the weekly price variation is explained by the surprises in the Colorado and Iowa/Minnesota markets. These price impacts are confirmed by our separate regression results shown at the foot of table 4. Clearly, by focusing on unambiguous bull and bear market signals in *COF* reports over the full sample period, our results show that the primary price discovery markets are Texas/Oklahoma/New Mexico and Kansas. These results are perhaps not surprising given that the Texas/Oklahoma/New Mexico and Kansas markets accounted for around 50 – 70% of the overall volume of negotiated transactions/marketings over the sample period (Coffey, Pendell and Tonsor, 2019).

Large Bull and Bear Market Pricing Signals

We find similar results when we further breakdown the consistent bull and bear market data to focus only on large surprises to placements and marketings. The correlations between surprises and prices presented in table 3 and the large bull and bear market pricing signal regression results shown in table 6 again highlight the importance of Texas/Oklahoma/New Mexico and Kansas markets for price discovery. Again, *COF* surprises account for twice as much of the weekly price variation in these markets compared with Colorado and Iowa/Minnesota markets.

Consistent Bull and Bear Market Pricing Signals over the 2004 – 2013 versus the 2014 – 2020 period

Tables 7 and 8 show surprise and price correlations over the 2004 – 2013 and 2014 – 2020 periods, respectively. The most noticeable difference is that the correlations between placement and marketings surprises and all LMPR cash prices has doubled over the more recent 2014 – 2020 period. LMPR cash markets are now more responsive than ever to unambiguous price signals contained in *COF* reports. Our regression model results presented in tables 9 and 10

confirm this finding. Turning first to table 9, our results highlight the important price discovery role played by Texas/Oklahoma/New Mexico and Kansas markets over this earlier period. R-squared values and F-tests are much larger for these two markets compared with the others and in particular the Colorado and Iowa/Minnesota markets. In contrast, the 2014 – 2020 regression results presented in table 10 with respect to R-squared values show that prices responsiveness and discovery is now more equally shared across LMPR markets. However, a word of caution is in order as the 2014 – 2020 results presented in table 10 are only based on 18 observations and are subject to high levels of multicollinearity. This issue is reflected in the lack of precision of the coefficient estimates (high standard errors) and insignificant F-tests.

Implications for the Fed Cattle Market

Because the fed cattle market has become a highly concentrated market characterized by a relatively low volume of negotiated cash transactions, questions about the efficiency and accuracy of prices ought to be taken very seriously: such markets are undoubtedly susceptible to price discovery problems, including intentional manipulation. Evidence of such problems in the fed cattle market is sparse, however, despite intense investigation by numerous researchers using varied data and methodology over many years. Results presented here are broadly consistent with those previous findings. Analysis of fed cattle cash price response to unanticipated information in the monthly *COF* report suggest that all regions respond to such information in a manner consistent with active price discovery – that is, prices adjust quickly and consistent with the expectations of economic theory in response to unanticipated information.

Much of the present concern over fed cattle price discovery has focused on the Texas/Oklahoma/New Mexico reporting region because of the relative thinness of negotiated trade in that region in recent years (see figure 4). The analysis presented here suggest that price

discovery in this region has actually been among the most active of any of the reporting regions over the period of this study. While negotiated prices in the region have become less responsive to unanticipated information since 2014, the (admittedly limited) data on response to information shocks since then does not suggest that the price discovery process in Texas/Oklahoma/New Mexico is notably different than in any other region, including regions (e.g., Nebraska, Iowa/Minnesota) with much higher proportions of negotiated transactions.

Summary and Conclusions

A clear understanding of price discovery processes and mechanisms in the fed cattle market is important because a number of policy interventions have been proposed with the specified intent of improving price discovery. Without question, the fed cattle market has thinned rather dramatically over the past decade or so in terms of negotiated spot market transactions as a share of total transactions. While this situation raises legitimate concerns – particularly in light of formula transactions that rely on negotiated trades for price benchmarks – there is little evidence that the effectiveness of price discovery in the fed cattle market has been compromised, either by the thinning of negotiated trade or by market concentration in the meatpacking sector.

The fact that the thin and highly-concentrated fed cattle market does not exhibit clear signs of non-competitive pricing behavior does not suggest that market participants should have no concerns about price discovery. The reliance of formula prices on negotiated prices is reason enough to pay particular attention to the manner in which prices are established in the market. Negotiated prices not only reveal information about supply and demand fundamentals in the fed cattle market; they also contribute substantially to formula prices that control two-thirds or more of fed cattle trades. For both of these reasons, negotiated trades in the fed cattle market have

some characteristics of a public good; therefore, market participants have a strong interest in ensuring that negotiated trades occur in sufficient quantity to fulfill this public good role (Koontz and Purcell, 1997). A number of complicated issues arise with respect to how this interest is best addressed. What volume of negotiated trades is necessary for efficient price discovery? Theory and empirical work, as reviewed in this volume, suggest that the figure may be quite small – smaller than market participants (at least on the selling side) are apparently comfortable with. If interventions to increase negotiated trade volume are undertaken, what form of intervention is appropriate? Market-based incentives or regulatory decree? In either case, it may well be that intervention disrupts the organic development of market institutions (both formal and informal) that are appropriate and effective for the circumstances of this particular market. After all, formula pricing has not been imposed on the fed cattle market by force: packers and feeders have mutually decided that it presents an effective and efficient way for them to transact routine business. It may well be that in seeking to preserve price discovery by familiar means, beneficial market innovations may be undermined, with unforeseen consequences for both individual market participants and for the sector as a whole.

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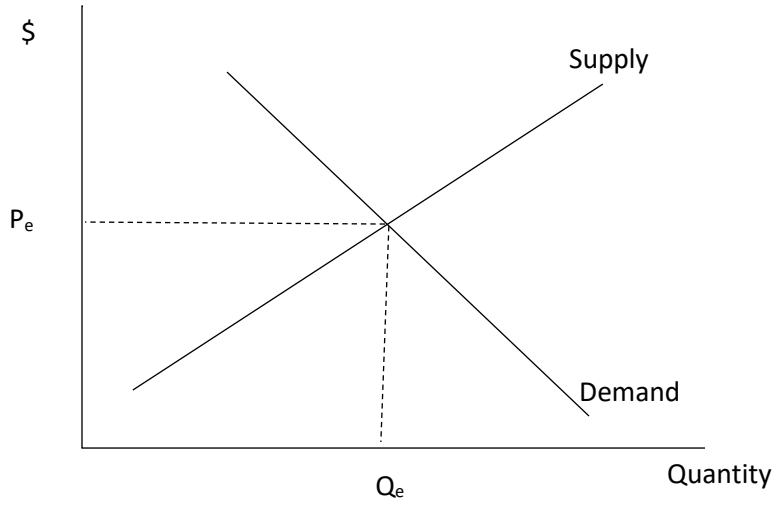
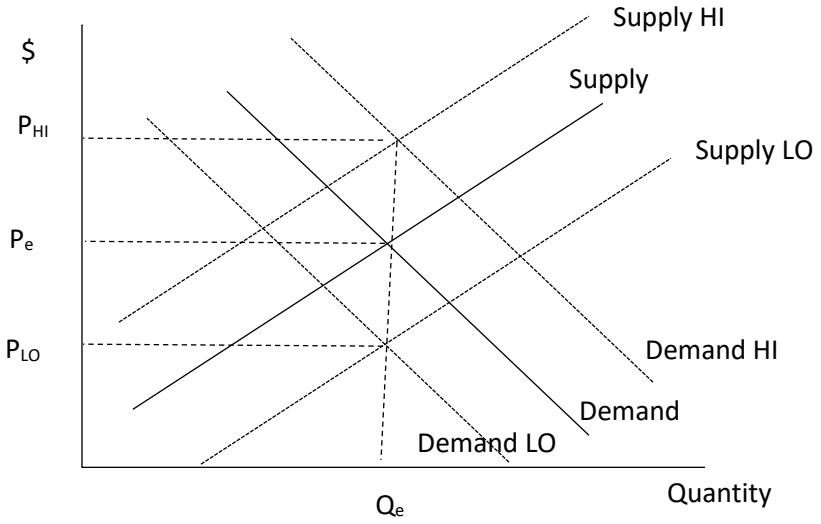


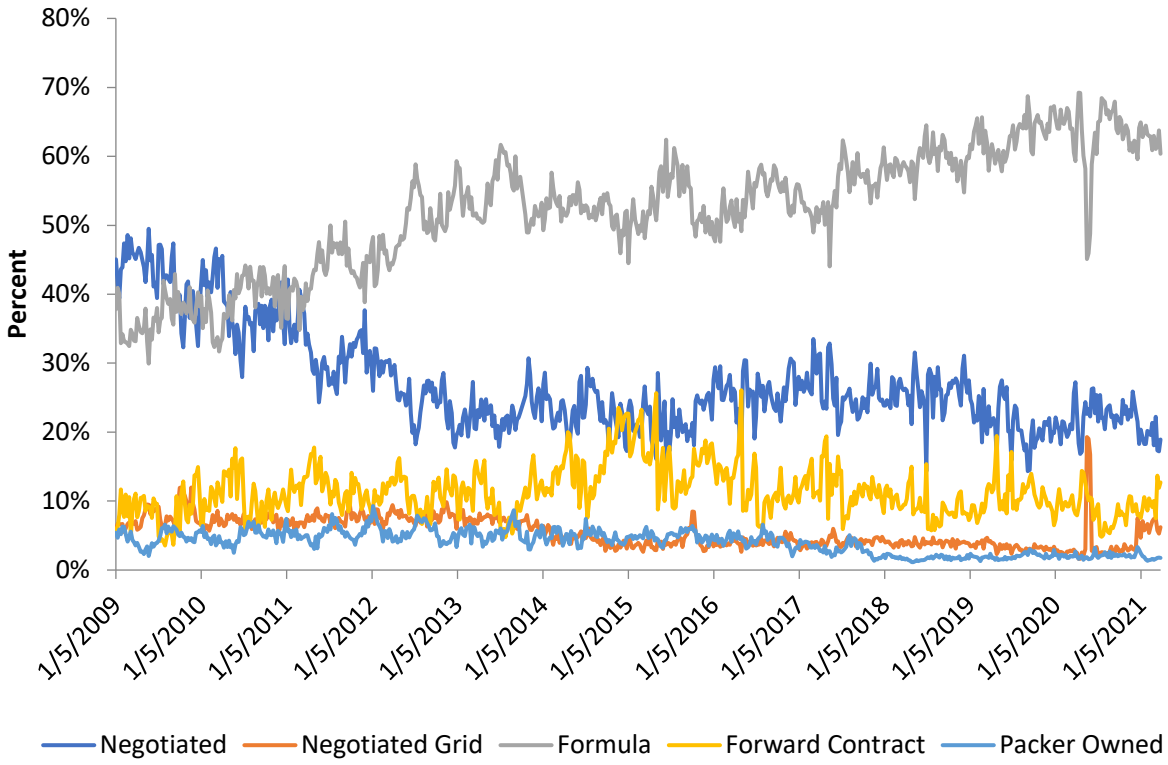
Notes: P_e and Q_e denote equilibrium price and quantity, respectively.

Figure 1. Price Determination in a Hypothetical Market



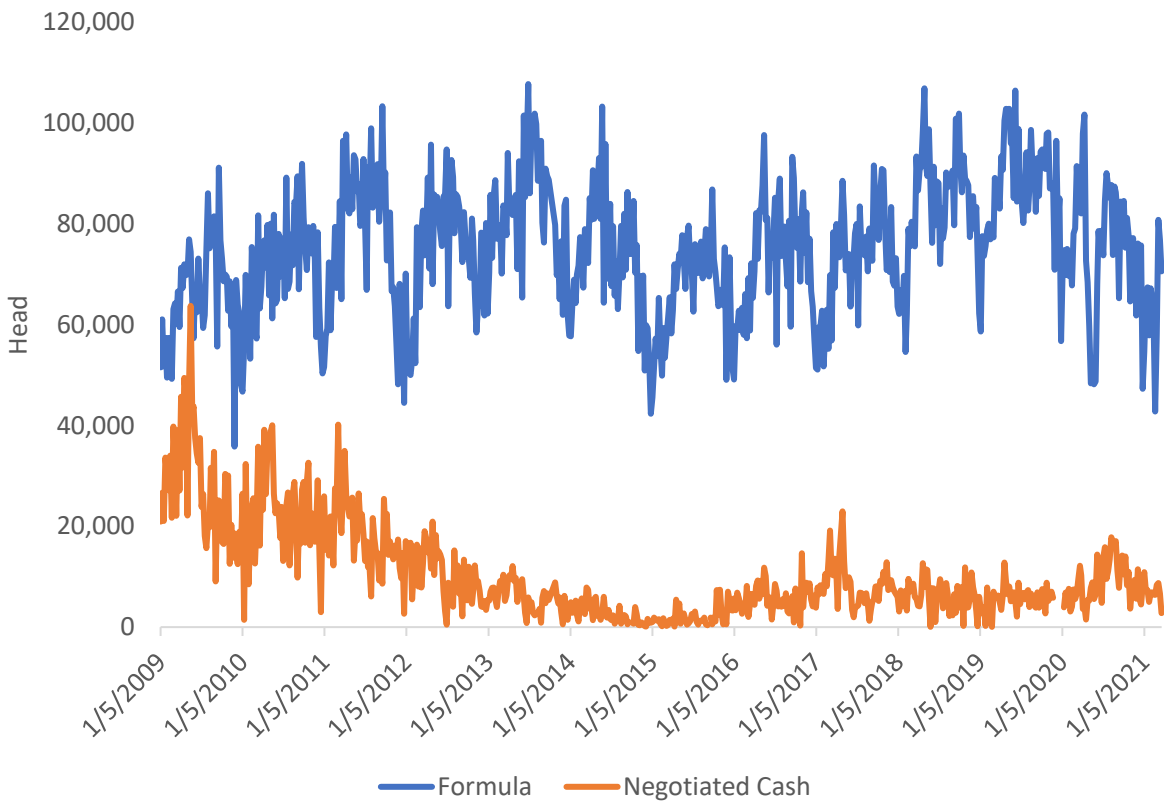
Notes: P_e and Q_e denote equilibrium price and quantity, respectively.

Figure 2. Price Discovery in a Hypothetical Market



Data Source: USDA Agricultural Marketing Service, Livestock, Poultry & Grain

Figure 3. Weekly Live Cattle Transactions by Type: Percent of Total Weekly Transactions



Data Source: USDA Agricultural Marketing Service, Livestock, Poultry & Grain

Figure 4. Weekly Live Cattle Transactions by Formula and Negotiated Cash Sales: Texas/Oklahoma Reporting Region

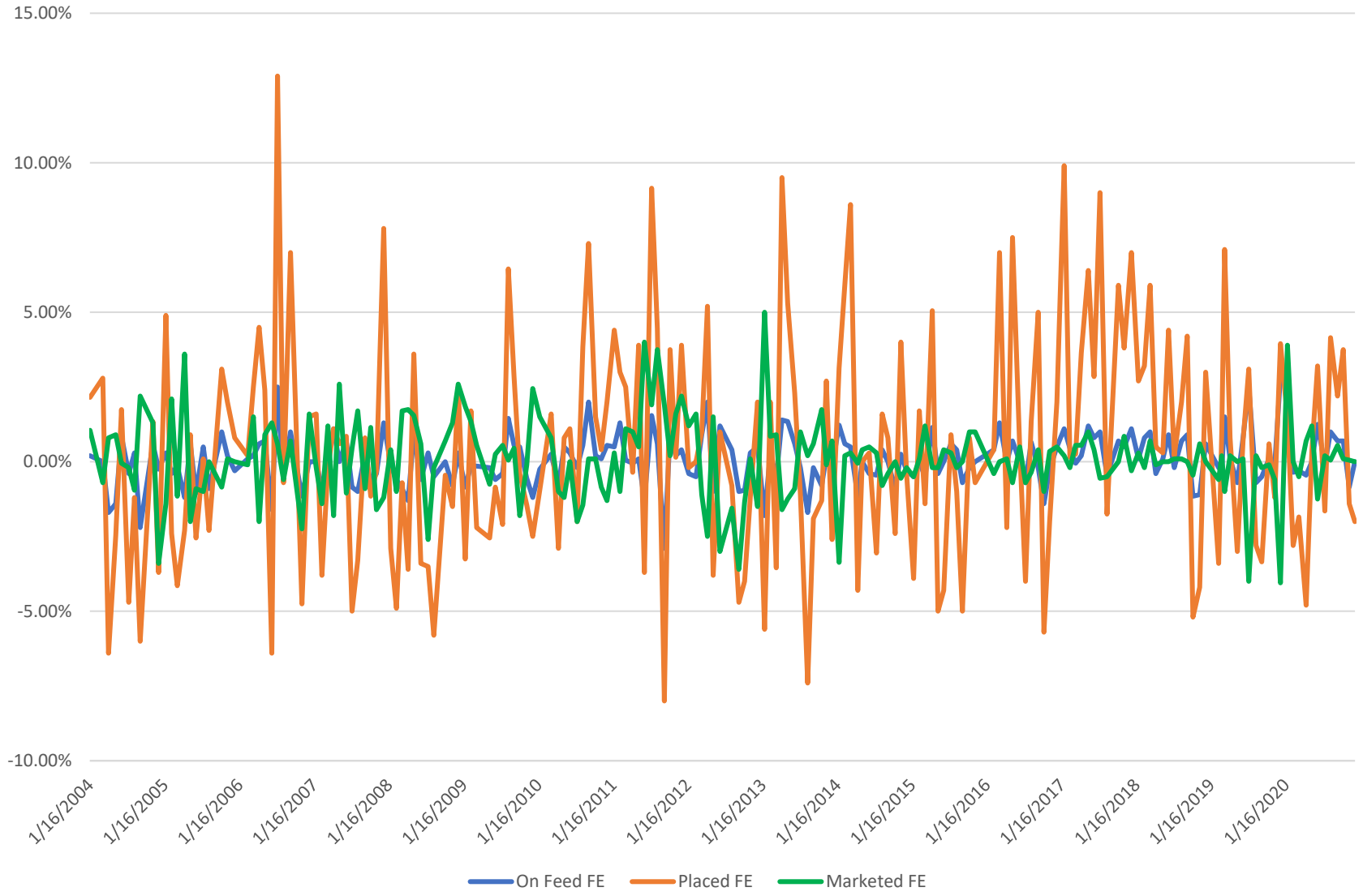


Figure 5. Market Surprises or Analyst Forecast Errors of Cattle on Feed, Placements and Marketings: 1/16/04 – 12/18/20

Table 1. Correlations between Weekly Changes in Negotiated Live Cattle Cash Prices and Market Surprises to Cattle on Feed, Placements and Marketings 1/16/04 – 12/18/20

	Feed	Placed	Marketed	Texas[a]	Kansas	Nebraska	Colorado	Iowa[b]
Feed	1	0.81**	-0.31**	-0.14**	-0.13*	-0.11	-0.10	-0.12*
Placed		1	-0.10	-0.12*	-0.13*	-0.10	-0.11	-0.12*
Marketed			1	0.10	0.08	0.09	0.13*	0.06
Texas[a]				1	0.98**	0.93**	0.93**	0.90**
Kansas					1	0.94**	0.94**	0.91**
Nebraska						1	0.96**	0.94**
Colorado							1	0.91**
Iowa[b]								1

* indicates the Pearson correlation coefficient is significant at the 10% level on a two tailed test.
** indicates the Pearson correlation coefficient is significant at the 5% level on a two tailed test.
[a]Texas refers to the Texas-Oklahoma-New Mexcio market.
[b]Iowa refers to the Iowa-Minnesota market.

Table 2. Response of Negotiated Live Cattle Cash Prices to Market Surprises in Placements and Marketings 1/16/04 – 12/18/20

Parameters	Texas[a]	Kansas	Nebraska	Colorado	Iowa[b]
Intercept	0.002	0.003	0.003	0.003	0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Placed	-0.074	-0.076*	-0.063	-0.060	-0.069
	(0.046)	(0.045)	(0.047)	(0.048)	(0.042)
Marketed	0.154	0.122	0.142	0.217	0.073
	(0.130)	(0.125)	(0.132)	(0.139)	(0.118)
R-Squared	0.023	0.021	0.017	0.026	0.017
LM(1)	0.528	1.018	0.297	0.369	0.132
	(0.467)	(0.313)	(0.586)	(0.544)	(0.716)
B-P	0.446	0.198	0.312	0.188	0.751
	(0.800)	(0.906)	(0.855)	(0.910)	(0.687)
F Test	2.169	2.058	1.632	2.198	1.648
	(0.117)	(0.131)	(0.198)	(0.114)	(0.195)
Observations	188	192	192	166	192

Standard errors of coefficients are presented in parentheses in top half of table.
LM(1) is Breusch-Godfrey (Lagrange Multiplier test for first order autocorrelation). The test statistic is specified as Chi-Squared with 1 degree of freedom and p-values are presented in parentheses below the test statistic.
B-P is Breusch-Pagan test for heteroscedasticity and p-values are presented in parentheses below the test statistic.
F-test for the hypothesis that all of the coefficients (excluding the constant) are zero with p-values in parentheses.
*Indicates significance at the 10% level.
**Indicates significance at the 5% level.
*** Indicates significance at the 1% level.
[a]Texas refers to the Texas-Oklahoma-New Mexcio market.
[b]Iowa refers to the Iowa-Minnesota market.

Table 3. Correlations between Weekly Changes in Negotiated Live Cattle Cash Prices and Market Surprises with consistent Bull or Bear Market Surprises to Placements and Marketings 1/16/04 – 12/18/20

	Feed	Placed	Marketed	Texas[a]	Kansas	Nebraska	Colorado	Iowa[b]
Feed	1	0.86**	-0.80**	-0.25**	-0.23**	-0.19*	-0.15	-0.14
Placed		1	-0.67**	-0.29**	-0.30**	-0.24**	-0.23**	-0.20*
Marketed			1	0.27**	0.26**	0.24**	0.20*	0.21*
Texas[a]				1	0.97**	0.89**	0.89**	0.84**
Kansas					1	0.92**	0.93**	0.87**
Nebraska						1	0.95**	0.94**
Colorado							1	0.88**
Iowa[b]								1

* indicates the Pearson correlation coefficient is significant at the 10% level on a two tailed test.
** indicates the Pearson correlation coefficient is significant at the 5% level on a two tailed test.
79 observations.
[a]Texas refers to the Texas-Oklahoma-New Mexcio market.
[b]Iowa refers to the Iowa-Minnesota market.

Table 4. Response of Negotiated Live Cattle Cash Prices to Consistent Bull or Bear Market Surprises in Placements and Marketings 1/16/04 – 12/18/20

Parameters	Texas[a]	Kansas	Nebraska	Colorado	Iowa[b]
Intercept	0.001	0.001	-0.000	0.000	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Placed	-0.102	-0.118	-0.078	-0.100	-0.049
	(0.074)	(0.078)	(0.080)	(0.084)	(0.076)
Marketed	0.183	0.154	0.203	0.119	0.198
	(0.195)	(0.205)	(0.211)	(0.221)	(0.199)
R-Squared	0.096	0.094	0.070	0.057	0.051
LM(1)	0.562	0.617	0.365	0.171	0.293
	(0.453)	(0.432)	(0.546)	(0.679)	(0.588)
B-P	2.116	0.880	1.053	0.244	1.705
	(0.347)	(0.644)	(0.591)	(0.885)	(0.426)
F Test	4.028**	3.955**	2.847*	2.303	2.058
	(0.022)	(0.023)	(0.064)	(0.107)	(0.135)
Observations	79	79	79	79	79
Placed	-0.148***	-0.157***	-0.130**	-0.130**	-0.100*
	(0.055)	(0.058)	(0.060)	(0.062)	(0.056)
R-Squared	0.085	0.087	0.058	0.054	0.039
Marketed	0.361**	0.361**	0.341**	0.294*	0.285*
	(0.146)	(0.153)	(0.156)	(0.165)	(0.148)
R-Squared	0.074	0.067	0.058	0.040	0.046

Standard errors of coefficients are presented in parentheses in top half of table.
LM(1) is Breusch-Godfrey (Lagrange Multiplier test for first order autocorrelation). The test statistic is specified as Chi-Squared with 1 degree of freedom and p-values are presented in parentheses below the test statistic.
B-P is Breusch-Pagan test for heteroscedasticity and p-values are presented in parentheses below the test statistic.
F-test for the hypothesis that all of the coefficients (excluding the constant) are zero with p-values in parentheses.
*Indicates significance at the 10% level.
**Indicates significance at the 5% level.
*** Indicates significance at the 1% level.
[a]Texas refers to the Texas-Oklahoma-New Mexcio market.
[b]Iowa refers to the Iowa-Minnesota market.

Table 5. Correlations between Weekly Changes in Negotiated Live Cattle Cash Prices and Market Surprises with only large Surprises in both Marketings and Placements with consistent Bull or Bear Market Surprises to Placements and Marketings 1/16/04 – 12/18/20

	Feed	Placed	Marketed	Texas[a]	Kansas	Nebraska	Colorado	Iowa[b]
Feed	1	0.88**	-0.81**	-0.35**	-0.32**	-0.25*	-0.23*	-0.19
Placed		1	-0.67**	-0.33**	-0.32**	-0.23*	-0.23*	-0.17
Marketed			1	0.33**	0.32**	0.27*	0.24*	0.25*
Texas[a]				1	0.97**	0.87**	0.89**	0.82**
Kansas					1	0.91**	0.93**	0.86**
Nebraska						1	0.96**	0.94**
Colorado							1	0.89**
Iowa[b]								1

* indicates the Pearson correlation coefficient is significant at the 10% level on a two tailed test.
** indicates the Pearson correlation coefficient is significant at the 5% level on a two tailed test.
55 observations.
[a]Texas refers to the Texas-Oklahoma-New Mexcio market.
[b]Iowa refers to the Iowa-Minnesota market.

Table 6. Response of Negotiated Live Cattle Cash Prices to only large Surprises in both Marketings and Placements with consistent Bull or Bear Market Surprises to Placements and Marketings 1/16/04 – 12/18/20

Parameters	Texas[a]	Kansas	Nebraska	Colorado	Iowa[b]
Intercept	-0.001	-0.002	-0.003	-0.002	-0.004
	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
Placed	-0.083	-0.092	-0.039	-0.058	-0.008
	(0.075)	(0.080)	(0.083)	(0.085)	(0.079)
Marketed	0.225	0.215	0.259	0.191	0.265
	(0.196)	(0.207)	(0.215)	(0.221)	(0.205)
R-Squared	0.129	0.123	0.079	0.066	0.061
LM(1)	0.260	0.084	0.273	0.381	0.452
	(0.610)	(0.772)	(0.601)	(0.537)	(0.501)
B-P	2.110	0.927	0.451	0.015	1.306
	(0.348)	(0.629)	(0.798)	(0.993)	(0.521)
F Test	3.862**	3.659**	2.220	1.828	1.681
	(0.027)	(0.033)	(0.119)	(0.171)	(0.196)
Observations	55	55	55	55	55
Placed	-0.141**	-0.148**	-0.106*	-0.107*	-0.076
	(0.056)	(0.059)	(0.061)	(0.063)	(0.059)
R-Squared	0.107	0.105	0.053	0.052	0.031
Marketed	0.370**	0.376**	0.327**	0.292*	0.278*
	(0.145)	(0.154)	(0.158)	(0.163)	(0.150)
R-Squared	0.109	0.101	0.075	0.057	0.061

Standard errors of coefficients are presented in parentheses in top half of table.
LM(1) is Breusch-Godfrey (Lagrange Multiplier test for first order autocorrelation). The test statistic is specified as Chi-Squared with 1 degree of freedom and p-values are presented in parentheses below the test statistic.
B-P is Breusch-Pagan test for heteroscedasticity and p-values are presented in parentheses below the test statistic.
F-test for the hypothesis that all of the coefficients (excluding the constant) are zero with p-values in parentheses.
*Indicates significance at the 10% level.
**Indicates significance at the 5% level.
*** Indicates significance at the 1% level.
[a]Texas refers to the Texas-Oklahoma-New Mexcio market.
[b]Iowa refers to the Iowa-Minnesota market.

Table 7. Correlations between Weekly Changes in Negotiated Live Cattle Cash Prices and Market Surprises with consistent Bull or Bear Market Surprises to Placements and Marketings 2004 – 2013

	Feed	Placed	Marketed	Texas[a]	Kansas	Nebraska	Colorado	Iowa[b]
Feed	1	0.88**	-0.81**	-0.22*	-0.21	-0.18	-0.15	-0.12
Placed		1	-0.71**	-0.25*	-0.25*	-0.21*	-0.20	-0.16
Marketed			1	0.29*	0.27*	0.24*	0.20	0.21
Texas[a]				1	0.97**	0.88**	0.90**	0.83**
Kansas					1	0.91**	0.93**	0.87**
Nebraska						1	0.96**	0.94**
Colorado							1	0.89**
Iowa[b]								1

* indicates the Pearson correlation coefficient is significant at the 10% level on a two tailed test.
** indicates the Pearson correlation coefficient is significant at the 5% level on a two tailed test.
61 observations.
[a]Texas refers to the Texas-Oklahoma-New Mexcio market.
[b]Iowa refers to the Iowa-Minnesota market.

Table 8. Correlations between Weekly Changes in Negotiated Live Cattle Cash Prices and Market Surprises with consistent Bull or Bear Market Surprises to Placements and Marketings 2014 – 2020

	Feed	Placed	Marketed	Texas[a]	Kansas	Nebraska	Colorado	Iowa[b]
Feed	1	0.84**	-0.72**	-0.43*	-0.38	-0.40	-0.31	-0.44*
Placed		1	-0.70**	-0.43*	-0.45*	-0.43*	-0.41*	-0.46*
Marketed			1	0.33	0.37	0.46*	0.41*	0.44*
Texas[a]				1	0.98**	0.95**	0.89**	0.93**
Kansas					1	0.96**	0.95**	0.92**
Nebraska						1	0.92**	0.95**
Colorado							1	0.86**
Iowa[b]								1

* indicates the Pearson correlation coefficient is significant at the 10% level on a two tailed test.
** indicates the Pearson correlation coefficient is significant at the 5% level on a two tailed test.
18 observations.
[a]Texas refers to the Texas-Oklahoma-New Mexcio market.
[b]Iowa refers to the Iowa-Minnesota market.

Table 9. Response of Negotiated Live Cattle Cash Prices to Consistent Bull or Bear Market Surprises in Placements and Marketings 2004 – 2013

Parameters	Texas[a]	Kansas	Nebraska	Colorado	Iowa[b]
Intercept	0.000	0.000	-0.001	-0.001	-0.002
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
Placed	-0.048	-0.063	-0.050	-0.068	-0.007
	(0.093)	(0.097)	(0.104)	(0.107)	(0.101)
Marketed	0.255	0.222	0.228	0.151	0.249
	(0.207)	(0.216)	(0.232)	(0.239)	(0.225)
R-Squared	0.086	0.078	0.061	0.045	0.045
LM(1)	0.177	0.160	1.508	0.475	0.487
	(0.674)	(0.689)	(0.220)	(0.491)	(0.485)
B-P	0.434	0.151	0.756	0.211	1.384
	(0.805)	(0.927)	(0.685)	(0.900)	(0.501)
F Test	2.713*	2.451*	1.889	1.368	1.358
	(0.075)	(0.095)	(0.161)	(0.263)	(0.265)
Observations		61	61	61	61
Placed	-0.129*	-0.134*	-0.123*	-0.116	-0.087
	(0.066)	(0.068)	(0.073)	(0.075)	(0.071)
R-Squared	0.062	0.061	0.045	0.039	0.024
Marketed	0.331**	0.322**	0.308*	0.257	0.260
	(0.145)	(0.151)	(0.162)	(0.167)	(0.157)
R-Squared	0.081	0.071	0.057	0.039	0.045

Standard errors of coefficients are presented in parentheses in top half of table.
LM(1) is Breusch-Godfrey (Lagrange Multiplier test for first order autocorrelation). The test statistic is specified as Chi-Squared with 1 degree of freedom and p-values are presented in parentheses below the test statistic.
B-P is Breusch-Pagan test for heteroscedasticity and p-values are presented in parentheses below the test statistic.
F-test for the hypothesis that all of the coefficients (excluding the constant) are zero with p-values in parentheses.
*Indicates significance at the 10% level.
**Indicates significance at the 5% level.
*** Indicates significance at the 1% level.
[a]Texas refers to the Texas-Oklahoma-New Mexcio market.
[b]Iowa refers to the Iowa-Minnesota market.

Table 10. Response of Negotiated Live Cattle Cash Prices to Consistent Bull or Bear Market Surprises in Placements and Marketings 2014 – 2020

Parameters	Texas[a]	Kansas	Nebraska	Colorado	Iowa[b]
Intercept	0.005	0.005	0.005	0.006	0.004
	(0.005)	(0.006)	(0.005)	(0.006)	(0.004)
Placed	-0.210	-0.208	-0.104	-0.137	-0.126
	(0.174)	(0.184)	(0.158)	(0.182)	(0.133)
Marketed	0.199	0.451	1.042	0.887	0.669
	(1.198)	(1.264)	(1.084)	(1.250)	(0.916)
R-Squared	0.189	0.207	0.230	0.195	0.241
LM(1)	0.823	0.824	1.159	0.368	0.359
	(0.364)	(0.364)	(0.282)	(0.544)	(0.549)
B-P	0.478	0.229	0.123	0.617	0.797
	(0.788)	(0.892)	(0.941)	(0.735)	(0.671)
F Test	1.748	1.959	2.238	1.820	2.383
	(0.208)	(0.175)	(0.141)	(0.196)	(0.126)
Observations	18	18	18	18	18
Placed	-0.230*	-0.254*	-0.211*	-0.228*	-0.194*
	(0.120)	(0.127)	(0.112)	(0.127)	(0.093)
R-Squared	0.188	0.200	0.183	0.168	0.214
Marketed	1.216	1.457	1.547*	1.553*	1.279*
	(0.862)	(0.905)	(0.756)	(0.875)	(0.648)
R-Squared	0.111	0.140	0.207	0.165	0.196

Standard errors of coefficients are presented in parentheses in top half of table.
LM(1) is Breusch-Godfrey (Lagrange Multiplier test for first order autocorrelation). The test statistic is specified as Chi-Squared with 1 degree of freedom and p-values are presented in parentheses below the test statistic.
B-P is Breusch-Pagan test for heteroscedasticity and p-values are presented in parentheses below the test statistic.
F-test for the hypothesis that all of the coefficients (excluding the constant) are zero with p-values in parentheses.
*Indicates significance at the 10% level.
**Indicates significance at the 5% level.
*** Indicates significance at the 1% level.
[a]Texas refers to the Texas-Oklahoma-New Mexcio market.
[b]Iowa refers to the Iowa-Minnesota market.