Impacts of Forward Contract Information on Market Pricing and Production Efficiency in a Simulated Fed Cattle Market Experiment

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Abstract

An economic experiment was designed to measure the impacts of providing forward contract information in a simulated fed cattle market, where prices are discovered through private bilateral negotiation. This forward contract information is similar to that provided by the USDA Agricultural Marketing Service under the legislated mandatory price reporting. Results indicate that provision of that information reduced price dispersion and reduced price levels. The reduced levels are consistent with intuition from a bilateral negotiation model and with other research, but are likely surprising to industry personnel and policy makers. The system also produced animals at lower total costs with provision of this information. These results suggest that policies aimed at improving transparency in markets where price discovery does not occur in a purely competitive institution and where advance-production decisions are made may not improve sellers' outcomes.

Key words: bilateral negotiation, mandatory price reporting, market information

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Introduction

Agricultural production is increasingly sold through bilaterally negotiated forward contracts rather than spot markets (Key and MacDonald, 2006). The evolution from auctions and centralized marketplaces to private negotiations has been a source of interest and concern regarding price discovery in cattle markets (Koontz and Purcell, 1997). This change has potentially resulted in less price information and less accurate market price reports being available to participants as cash trade volumes decline. The USDA estimates that under the current market news reporting program 35-40% of cattle transactions are not reported (USDA AMS, n.d.). Policy makers, usually at the behest of producer groups, have been willing to intervene in agricultural markets with the purpose of improving information and thereby competitiveness. However, unintended impacts can occur from policies designed to improve markets that do not conform to the assumptions of pure competition, i.e., in a world of second best choices (see Rausser et al., 1987 and Bonnen and Schweikhardt, 1998).

A recent example of policy makers changing market regulations with the goal of improving competition through changing the available market information set is the amendment to the *Agricultural Marketing Act of 1946*, commonly referred to as "Mandatory Price Reporting," (USDA AMS, n.d.). The intent of mandatory price reporting (MPR) legislation was to provide information on forward contract and formula transactions in livestock markets. While this legislation ultimately expired in the fall of 2005, the USDA Agricultural Marketing Service (AMS) continues the program on a voluntary reporting basis, and more recently a rule was

proposed by the USDA to continue mandatory price reporting (USDA AMS, 2007).[1] Stakeholders of the MPR legislation and users of the current voluntarily reported information can benefit from an assessment of the impact from the provision of such information on cattle market outcomes. More generally, research regarding the impact of forward contract information can provide useful insights for future policies aimed at improving the bargaining position of sellers in agricultural markets that are becoming dominated by privately negotiated transactions. Thus, our research objective is to investigate the impact of the provision of forward contract information on market price level, price variability, and production efficiency in a simulated fed cattle market.

Analytical Approach: The Need for a Controlled Market Environment

Traditionally, research in agricultural markets addressing information questions has been conducted on markets, such as futures markets, that can be characterized as competitive. Futures markets involve a double oral auction trading institution and many potential buyers and sellers. Much of this research suggests that information can affect pricing efficiency (Colling and Irwin, 1990; Colling, Irwin, and Zulauf, 1997; Grunewald, McNulty, and Beire, 1993). However, such research provides little guidance as to the impact of new information in an imperfectly competitive market environment, as is found in cash fed cattle markets.

Methods of analysis using secondary data require a policy to be in place for a length of time before impacts can be estimated, often to the dismay of policy makers and market agents. Secondary data are not available for *ex-ante* analyses. Moreover, to analyze pre- and post impacts of a policy requires that all else be held constant. Meeting *ceteris paribus* conditions with properly specified econometric models would be difficult. While MPR has been in

existence since 2001, and there has been research that has compared prices for cattle sold under alternative marketing institutions (Perry et al., 2005), a case can be made that all else was not constant for these analyses. Other events during the institution of MPR provide potential shocks that could be difficult to control in traditional econometric models. These events include the significant improvement in domestic beef demand since 1998, the changing supply due to the cattle cycle and its interaction with persistent drought from 2001 through 2004, the discovery of bovine spongiform encephalopathy (BSE) in Canada in 2002 and the two-year closure of the border to live animal trade, and the discovery of BSE in the U.S. in 2003 and the closure of a number of important export markets. Thus, isolating the impact of changing the market information set can be done in an experimental setting if traditional econometric approaches are not be able to control all other market shocks. A laboratory test allows different parameters to be controlled, observed, and analyzed. The experiment is also replicated with multiple replications where the underlying supply and demand conditions are identical, where real-world complexities and uncertainties are abstracted from, and where only the information set is different.

For these reasons, the Fed Cattle Market Simulator (FCMS) developed at Oklahoma State University is used to provide the laboratory market environment to achieve our research objective. The research reported herein is unique in that it provides an experimental comparison of spot and forward contract prices with and without MPR-type forward contract information under identical supply and demand scenarios. Five replications of a market with reported forward contract information are compared to five replications without provision of forward contract information. Transactions data from experiments where forward contract information is provided will be compared using econometric models and to the same scenario where forward

contract information is not provided. The econometric models evaluate transaction price levels, price variability, and production efficiency under the two experimental treatments of forward contracting information. The research reported in this paper is an extension of Anderson et al. (1998), which examined the effects of reducing public information in fed cattle markets.

Review of Studies Evaluating the Impact of Market Information

The efficiency of a market in discovering price is affected by the information available to market actors. Grossman and Stiglitz (1980) indicate that an increase in the quality of information will increase the information content of prices. Stigler (1961) indicates that price dispersion can be a result of incomplete information on the part of market actors.

Research in agricultural markets suggests that information can affect price discovery and price variability. Colling and Irwin (1990) found that live hog futures prices adjusted to unanticipated information in the USDA *Hogs and Pigs* reports. Colling, Irwin, and Zulauf (1997) indicated that nearby pork belly and live hog futures prices were significantly affected by the release of the USDA *Cold Storage* report. Grunewald, McNulty, and Beire (1993) reported that live cattle futures prices responded to unexpected information in USDA *Cattle on Feed* reports. Each of these studies used analyses aimed at testing the efficiency of the futures market in incorporating information from government reports. Given that prices were impacted by unanticipated information, the authors conclude the reports do contain important information and that these reports fulfill their public policy mission.

Research in financial markets indicates that the transparency of the market (i.e., public disclosure of trade and quote information) is important in market efficiency and price discovery. Bloomfield and O'Hara (1999) tested the effects of trade and quote disclosure on market

efficiency using experimental laboratory currency markets. They concluded that trade disclosure increased informational efficiency of transaction prices. Flood et al. (1999) examined the effects of price disclosure in a continuous experimental multiple-dealer market. Public price queues were compared with bilateral quoting. Flood et al. (1999) concluded that higher search costs reduced trade volume and induced aggressive pricing strategies that increased the speed of price discovery in markets with bilateral quotes. Pagano and Röell (1996) investigated differing levels of transparency in several market types. Their results suggest that greater transparency generated lower trading costs for uninformed traders. Overall, the above research indicates that increased information reduces risk or costs for market participants as they form price expectations and discover prices.

The above studies focused primarily on the efficiency of futures or stock prices when incorporating information rather than price impacts in cash markets associated with new information. Moreover, the above studies were conducted in market environments that closely resembled a purely competitive market structure. Fed cattle markets have been shifting to more price discovery taking place via private negotiation (RTI International, 2007) and an overall market structure that is characterized by increasing firm concentration. Given that this market environment can be characterized as becoming more imperfectly competitive, conclusions drawn from the above studies regarding changing information sets in fed cattle markets seems dubious at best.

Imperfect information creates uncertainty when market participants discover price. The provision of forward contract information like that through MPR should improve the public information set. Publicly reported information on terms of trade and intended delivery dates for

forward contracted cattle may do more than have a simple impact on price. The information could affect the timing of marketings, the volume of cattle sold in the cash market, the prices of cattle sold in the cash market, and cattle weights at the time of delivery. Changing the public information set could result in substantial changes in cash and forward market behavior. As such, understanding how changing market information impacts imperfectly competitive markets is more relevant to our research objective.

Pendell and Schroeder (2006) investigate the spatial integration of market information across five regional fed cattle markets in the U. S. The authors use cointegration tests to analyze price relationships across five regional cattle markets before and after MPR was in effect. The authors conclude that the markets became more integrated, i.e., "prices tend to move more closely one-for-one following" (p. 577) the addition of information from MPR. Their research, however, does not provide an indication of impacts on price level or dispersion.

Albæk, Møllgaard, and Overgaard (1997) investigated the impact of published firm-specific transactions prices for ready-mixed concrete in three regions of Denmark. The authors concluded that publication of these prices had the unintended consequences of allowing firms to reduce the intensity of oligopoly price competition, and this led to increased consumer prices for concrete rather than reduced prices, as was intended by the regulatory agency. This work hints at the extent to which changes in information can affect price discovery in markets that are not purely competitive.

Anderson et al. (1998) examined how a reduction in public cash market information affected fed cattle markets. Reducing public information was found to increase price variance and decreased production efficiency for fed cattle. While the research by Anderson et al. (1998)

provides an experimental and econometric framework with which to achieve our research objective, the authors do not address the impact of data specific to that revealed through provision of forward contract information on fed cattle prices. The information changes considered in Anderson et al. (1998) consisted of an elimination of supply reports provided by the USDA National Agricultural Statistics Service – specifically the *Cattle on Feed* report and an elimination of USDA AMS functions of price reporting.

Azzam (2003) developed a theoretical oligopsonistic model to represent downstream firms (packers) and upstream firms (feedlots) and used comparative statics to test the impact of increased transparency due to mandatory price reporting. The analysis indicates that a change in conduct, output, and market share is a function of the marginal cost of reporting information, a direct effect from pooling by packers and an indirect effect from each packer's output decision. The author concludes that the increased transparency improved packer competition, increased output, reduced consumer prices, and increased feeder cattle prices. Azzam (2003) further concludes that the aggregated nature of data from mandatory price reporting reduced the ability of packers to use the information for oligopsonistic coordination.

Grunewald, Schroeder, and Ward (2004) conducted a survey of feedlots in Kansas, Iowa, Texas, and Nebraska regarding managers' opinions about the effectiveness of MPR. Responses were received from 22% of the 1504 feedlots surveyed. The authors used descriptive statistics and ordered logit models to test feedlot managers' perceptions regarding the benefits of MPR to the feeding industry, the increase in overall price information, and any enhanced ability of feedlots to negotiate prices with packers. Overall, responses ranged from neutral to negative regarding perceived benefits of MPR. Results indicated feedlots in Texas and Kansas were more

likely to respond negatively to questions regarding the benefits of MPR. The authors conclude expectations about the potential benefits of information from MPR may have been unrealistic.

Wachenheim and DeVuyst (2001) made use of the economic literature to develop hypotheses about the impact of MPR on livestock markets. They concluded that, depending on how mandatory price reporting is implemented, the price paid to livestock producers could be reduced with added market information. However, the authors did not provide empirical evidence to support this conclusion. The findings are conceptual arguments and provide the basis for stating hypotheses. Further, their results are somewhat supported by Grunewald, Schroeder, and Ward (2004).

Theoretical Model of Bilateral Negotiation

Our research extends the existing literature. A model of bilaterial negotiation is presented to offer an explanation of differences in spot and forward contracting market prices. This framework provides an alternative to the work by Azzam (2003) and Wachenheim and DeVuyst (2001). Our theoretical model is then empirically tested using data from an economic experiment. Empirical testing adds to the literature in that most of the previous work is conceptual and explores possible ramifications of altering information sets available on forward contract transactions in fed cattle markets. Further, this work is unique in its experimental nature. There is little possibility to conduct the same analysis with real-world data.

An adaptation of the model reported by Menkhaus et al. (1999) using Robison and Barry's (1987) expected value-variance (EV) approach provides a theoretical baseline for understanding the research problem. Fed cattle markets are typified by bilateral negotiation between an agent for the packer and an agent for the feedlot. This can be modeled in a private

negotiation framework where price (p) becomes a function of quantity (q), given there is one buyer and one seller for each transaction. As such, the expected price for the seller is $E(p(q) + \omega + \varepsilon) = p(q)$, where ω and ε are random variables with expected values of zero and variances of σ^2_ω and σ^2_ε. The distributions of ω and ε are assumed to be such that price cannot be negative. The random variable ω represents the risk the seller faces associated with sunk costs incurred due to advanced production of the commodity, i.e., the seller risks losing production costs if the commodity is not sold. The random variable ε represents the risk associated with reduced information, i.e., no forward contract information.

Under this price scenario, the expected profit for the seller is $E(\pi) = p(q)q - C(q)$ with variance $q^2\sigma^2_{\omega+\varepsilon} = q^2\sigma^2_\omega + q^2\sigma^2_\varepsilon + 2q^2\rho\sigma_\omega\sigma_\varepsilon$, where ρ is the correlation between ω and ε. The certainty equivalent of profit for the seller is:

(1) $\pi_{ce} = p(q)q - C(q) - (\lambda_S/2)(q^2\sigma^2_\omega + q^2\sigma^2_\varepsilon + 2q^2\rho\sigma_\omega\sigma_\varepsilon)$,

where λ_S is the Pratt-Arrow measure of risk attitude for the seller. The first-order conditions for the seller requires:

(2) $MR_S = p'(q)q + p(q) = C'(q) + \lambda_S (q\sigma^2_\omega + q\sigma^2_\varepsilon + 2q\rho\sigma_\omega\sigma_\varepsilon) = MC_S$.

Expected profit for the buyer is $E(\pi) = R(q) – p(q)q$ with variance $q^2\sigma^2_\varepsilon$. The certainty equivalent of the buyer's profit function is:

(3) $\pi_{ce} = R(q) - p(q)q - (\lambda_B/2)(q^2\sigma^2_\varepsilon)$.

The first order condition for the buyer requires:

(4) $MR_B = R'(q) = p'(q)q + p(q) + \lambda_B (q\sigma^2_\varepsilon) = MC_B$.

Both buyers and sellers incur risk due to the added cost associated with reduced information. The seller also has the additional cost of price risk resulting from production before

the sale. We assume the seller faces greater risk than the buyer. This seems reasonable given the large number of sellers from which packers can purchase from to meet plant capacity constraints. The quantity traded in this scenario is expected to decline, and total surplus, and thus market efficiency, will be reduced relative to the purely competitive case with full information. The potential impact of increased information is uncertain from the model. The negotiated price will depend on the relative risk preferences of the buyer and seller and also on differences in the variances of price risk attributable to production before sale for the seller and price information risk for both the seller and buyer.

The theoretical model and intuition suggest that bargaining power plays a role in determining the level of price in this setting of private negotiation with less than full information. It can be argued that the buyer is in a stronger bargaining position than the seller because buyers must understand that sellers have the risk of incurring additional costs of production if produced cattle are not sold at optimal (or close to optimal) weights (Menkhaus et al., 1999). Timely marketing is a risk to sellers. This advance-production risk puts sellers at a disadvantage relative to buyers even in the case of full information. However, the reduced risk associated with more information may in fact improve the bargaining position of the seller, assuming that buyers may have more knowledge of forward contracts than sellers without public reporting of such information. Due to the indeterminancy of impacts regarding the value of increased information for forward contracted cattle, empirical analysis is required to address our proposed hypotheses.

Lack of information is clearly a source of risk when market participants discover price. Conceptually, the provision of forward contract information could reduce this risk in livestock markets by increasing the public information set. Specifically, publicly reported information on

terms of trade and intended delivery dates for forward contracted cattle could affect the timing of all types of marketings, volume of cattle sold in the cash market, and cattle weights at the time of delivery. Several hypotheses are to be investigated in this study. The null hypotheses to be tested where information on forward contracts is made public are the following:

(1) H_0: Increased information will not affect price levels in forward or spot cattle markets.

(2) H_0: Increased information will not affect price variability in fed cattle markets.

(3) H_0: Increased information will not affect productive efficiency in cattle feeding.

Experimental Design and Procedure

Student participants in the forward contract information experiments were recruited from a senior-level agricultural commodity marketing class at Colorado State University during the five fall semesters from 2000-2004. The student participants were paid based on profitability of their team.[2] This was done to insure the conditions of monotonicity, salience, and dominance, which induce agent incentives consistent with economic theory (Friedman and Sunder, 1994). Two daylong experiment sessions were conducted each semester in which participants were expected to make transactions over a simulated period of at least 40 weeks where forward contract information was provided. Consistent with previous research using the FCMS, the first six weeks of trade data were dropped from the analysis to allow for learning (Anderson et al., 1998; Ward, 2005; Ward et al., 1999; Ward et al., 1996).

The baseline information observations came from simulations conducted with personnel from Excel Corporation in Wichita, Kansas, during five meetings in the winters of 1999-2003. While these participants were not paid, incentives were incorporated into the simulation. Limited information regarding team performance was revealed through a traveling trophy every

four trading periods for the team with the best profits and a trophy for the "best supporting" team, i.e., team with the least profits. Ward et al. (1996) reported that this method elicited competitive spirit from both student and corporate participants, and analyses of results from sessions with this as the only incentive were generally consistent with prior research on transaction prices using data collected from feedlots.

Several issues are important to note at this point. It is difficult, and in practice impossible, to have the participants play the simulation for more than two days. With the current experiment, students were required to participate for two Saturdays for a total of 15 hours. Industry participants conducted the simulator in an all-day Friday and all-day Saturday session. While student participants were paid, payoffs were a low reservation wage for time. The funds do reward good-play and penalize poor-play, but the real benefit of paying the students was to secure participants. Once they are there, their competitive nature and spirit take over.

The same general behavior is seen in all groups of participants. Industry participants are not paid, but non-payment likely is not an issue because industry participants self-select into the training exercise. It is one of several choices. The FCMS training has a reputation of being informative and enjoyable. Thus, the participants are genuinely interested. Whether there is money at risk or not, the commodity context of the simulation provides realism which motivates all participants. But, as discussed in Friedman and Sunder (1994), lengthy experiments introduce the possibility of participant fatigue. There is a time trade-off that must be made.

Two days are needed for the participants to learn the game and then play 40-45 weeks of market time, which begins with normal cattle numbers, proceeds through a large-supply scenario, through a small-supply scenario, and returns to normal numbers. It is important to

have the participants trade through the complete supply scenarios under a single institution. Variation in supplies is one of the most important features of agricultural commodity markets and we want to hold the reporting institutions constant. Dynamic experiments are not common in the experimental economics literature, but dynamics are a fact in real world markets.

The key elements of the experimental design include practices and features of the market simulator, market information provided to the participants for the baseline portion of the study, and market information provided to participants on forward contracts. A brief description of the FCMS and figure 1 are provided to better understand the simulated market environment experienced by participants. Other descriptions of the FCMS can be found in Anderson et al. (1998), Koontz et al. (1995 a and b), and Ward et al. (1996 and 1999).

Participants in the FCMS comprised eight feedlot teams and four meatpacking teams. Each team consisted of two to four persons. These teams bought and sold simulated pens of fed cattle during each trading week. Each trading week consisted of a ten-minute cycle. Feeders and packers negotiate transactions. Trades were conducted in face-to-face bilateral negotiations. Each feedlot has a number of op-scan paper pens of cattle representing the market-ready inventory–or showlist–with each pen containing 100 animals. Weights of animals on the showlist range from 1,100 to 1,200 pounds in five 25-pound increments. Cattle enter the showlist at 1,100 pounds. If they are not sold during the current trading week, they gain 25 pounds and are available for sale the following week. Cattle reach a maximum weight of 1,200 pounds in the FCMS.[3] Transactions were recorded on sheets representing pens of cattle that were scanned into a computer. Prior to the experiment, the rules and practices of the simulator were explained and practice sessions were held to familiarize participants with procedures

(figure 1).

Following each ten-minute trading period, a five-minute decision period allowed teams to process market information, update show lists, calculate breakeven prices, and develop strategies for subsequent trading periods. An income statement for each team documenting transactions of the previous trading period was provided during each decision period (see figure 1).

Each FCMS transaction represented a data point involving the sale and purchase of one pen of 100 animals between a feedlot and a packer. For each transaction, the following data were recorded: week traded, packer purchasing cattle, feedlot selling cattle, weight of cattle, transaction price and type of transaction (cash or forward contract). Other recorded data included breakeven prices, boxed beef price at which meat was sold, closing nearby futures price for cattle, total marketings, and number of pens of cattle on the industry showlist at the beginning of each trading week.

The FCMS software controls a number of aspects of the experiment based on researched economic relationships. The FCMS sells meat from cattle purchased last trading period into the boxed beef market this trading period and accounts for plant operation costs. Boxed beef prices are determined by a weekly boxed beef demand curve. Plant costs are determined by a U-shaped average total cost curve. Both are based on real-world parameters. The FCMS also purchases feeder cattle and keeps track of feedlot costs, and feedlot cattle inventories. All are simplifications but are based on real-world economic and animal physiology relationships.

The key feature of the experiment reported in this study was the market information provided during each trading period. Two digital displays provided the following information throughout each trading period. One display showed continuously updated cash transactions that

included trading volume and high-low price ranges, which is analogous to USDA AMS cash market information. The second display provided continuously updated trading volume and current prices for three live cattle futures market contracts which is analogous to the information available from the Chicago Mercantile Exchange.[4] Weekly summaries were also provided during the decision period – similar to USDA AMS summaries for boxed beef, fed cattle and feeder cattle prices, feed costs, and volumes. This information was available to participants throughout all sessions.

There is additional information provided to the participants during the replications with forward contract information. The forward market information included the volume of cattle purchased through forward contract by intended delivery week and the negotiated price range by delivery week. During this information treatment, the forward contract information summarized from the trading period was provided during the five-minute decision period. The baseline scenario for the experiment was based on the market information available to agents in the fed cattle market prior to mandatory price reporting (i.e., no forward contract information).

It is important to remember that while a number of features of the FCMS mimic a number of features of the real-world fed cattle market, the simulator controls all but the bilateral negotiation and the specific dynamics resulting from participant actions in the current trading week (i.e., the models that determine the dynamics are controlled). Thus, the market simulator has a specific commodity context similar to field experiments (see Harrison and List, 2004), but participants were actually trading slips of paper in an experimental setting that controlled essential elements.

Experimental Design Issues

There are two issues related to the experiment and experimental design that merit further discussion. First, are students appropriate economic agents? Second, is it appropriate to compare the student replications to industry member replications?

A review of Davis and Holt (1993), Kagel and Roth (1995), and Friedman and Sunder (1994) reveal that students are the most common agent used within economic experiments. Davis and Holt (1993) state that the concern over the use of students is a concern over choice of subjects for the experiment and that a variety of experimental economics research has shown that the behavior of decision makers recruited from naturally occurring markets is not different from standard student subject pools (p. 17). Thus, students are in fact appropriate economic agents.

At issue is if students think differently from real-world economic agents. Also at issue is the level of abstraction in the simulated market. Do the skills and experience that industry participants have impart an advantage in the simulator? These questions are the second issue– the comparison of five student replications (with forward contract information) to five industry replications (without forward contract information).[5] The remainder of this section will discuss and justify the student-industry comparison.

We contend that students can be compared to the industry participants in this experiment for a two basic reasons. First, the backgrounds of the students and industry participants are not dissimilar. The industry participants are from corporate headquarters, sales, plant operations, IT, international relations, procurement, and from the pork side of the company. Almost none of the industry members participate in actual trading for fed cattle market in their professional positions. Excel Corporation used the simulation for "cross-training" (see Koontz et al., 1995b).

The simulation shows participants the big picture of the procurement market in which the company operates. While some participants have years of experience with the company, many are close to entry level and almost all have comparable education and backgrounds to the student participants. Many are graduates from Land Grant University programs and other state universities. Thus, industry participants used in this experiment are not expected to have an advantage over students in the FCMS environment.

Second, the level of abstraction and control in the FCMS environment is sufficiently abstract to negate the use of rules of thumb or job-related intuition that could create irrational bargaining behavior on the part of industry participants compared to students (see Davis and Holt, 1993 for a discussion of business people). Davis and Holt (1993; p. 17) provide a list of early research that examines the difference between students and professionals in economic experiments. More recent work includes Haigh and List (2005) and Abbink and Rockenbach (2006). In summary, the literature finds that the behavior of the two groups are often not different when the groups are statistically different and the magnitudes are often not economically significant. However, the differences between students and professionals appears to be largest when the professionals are participating in an experiment most like their professional activities. For example, Abbink and Rokenbach (2006) find real-world options traders are different from students in an experimental options market. The authors attribute the difference to the fact that successful options traders need to assess an unknown underlying price distribution whereas the distribution in the experiment was controlled. Research summarized in Davis and Holt (1993) reveals that professionals are most like students in abstract experiments.

We contend that while there are specific commodity context attributes, the FCMS

environment provides sufficient control and abstraction from the participants' experiences and jobs. Because of the level of abstraction and the control of nuisance variables coupled with similar backgrounds and skills as it relates to bargaining in the FCMS, the industry and student participants are comparable. However, in the end, as with any experiment, the results are dependent on the sample. If there are fundamental differences in the groups of students and the groups of industry participants that extend across the ten replications, then results will reflect those differences, as well as the difference in market reporting institution.

Econometric Models and Data

Given the data generated from the previously discussed experiment, econometric models were used to evaluate the impact of forward contract information on transaction price levels, price variability, and production efficiency. These models follow the work reported in Anderson et al. (1998) and as developed from Jones et al. (1992), Schroeder et al. (1993), and Ward (1981, 1982, and 1992). The transaction data across the replications were used to estimate the following three models.

The price-level model is specified as follows:

(5) $$PRICE_{it} = \beta_o + \beta_1 BBP_{t-1} + \beta_2 FMP_{t-1} + \beta_3 TVOL_{t-1} + \beta_4 TINV_{t-1} + \beta_5 PPL_t + \beta_6 FDSZ_{it} + \beta_7 PKSZ_{it} + \beta_8 FWD_{it} + \beta_9 INFO_{it} + \beta_{10} INFO\times FWD_{it} + e_{it}$$

where t is the trading week and i denotes the transaction within the week. The number of trading weeks is somewhat variable depending on the length of play during each replication- 40 to 45 weeks. The number of transactions per week (i) depends on the participants and is variable. There are a few replications with small numbers of transactions and there are weeks with 60 pens traded, but the typical volume is 40 pens.

PRICE is the transaction price for each pen of fed cattle ($/cwt), BBP is the boxed beef price ($/cwt), FMP is the fed cattle futures market price ($/cwt), TVOL is the total pens of fed cattle slaughtered, TINV is the total number of pens of market-ready cattle, PPL is the potential profit or loss available to the industry, FDSZ is the size of the feedlot involved in the transaction relative to the smallest of the eight feedlots, PKSZ is the size of the packer involved in the transaction relative to the smallest of the four packers, FWD denotes the binary variable identifying type of sale (cash = 0; forward = 1), INFO denotes the binary variable identifying the provision of forward contract information (no forward contract information = 0; forward contract information = 1), and INFO×FWD is an interaction variable between INFO and FWD.

The price-level model is a standard model where transaction price is a function of market aggregate boxed beef price, cattle futures price, slaughter volume, and market-ready cattle inventories. The model is a reduced-form derived demand model that has been used by Anderson et al. (1998), Ward et al. (1996 and 1999) and Ward (2005) with data from the FCMS and follows Jones et al. (1992), Schroeder et al. (1993), Ward (1992), and Ward, Koontz, and Schroeder (1998) who use real-world cattle market data. Variables are lagged if they are simultaneously determined with the transaction price and are contemporaneous if they are predetermined the week of the transactions.

The potential profit is the dollars per cwt difference between the meatpacker breakeven and the feedlot breakeven price. This variable is included to measure if transaction price levels are different when the available profit is high or low. The feedlot/packer size variables measure if larger feedlots/packers paid higher or lower prices relative to the smallest operations in the industry. Or, is there a firm size impact on transaction price levels? The forward contracting

dummy variable measures if forward contract prices are higher or lower than spot transaction prices. Likewise, the information variable measures if the information on forward contracting impacts transaction prices.

The price-variance model is specified with the same independent variables as are in the price-level model, but the dependent variable is $\ln(e_{it}^2)$ where e_{it} the residual from the price-level model. The price-variance model is specified as follows:

$$(6) \quad \ln(e_{it}^2) = \alpha_o + \alpha_1 BBP_{t-1} + \alpha_2 FMP_{t-1} + \alpha_3 TVOL_{t-1} + \alpha_4 TINV_{t-1} + \alpha_5 PPL_t + \alpha_6 FDSZ_{it} + \alpha_7 PKSZ_{it} + \alpha_8 FWD_{it} + \alpha_9 INFO_{it} + \alpha_{10} INFO \times FWD_{it} + u_{it}$$

where variables are defined above. Independent variables in this model measure if variation in the variables of interest explain the unexplained variation in transaction prices. This price-variance model essentially measures price risk or price dispersion at the transaction level. It identifies the variables that explain the difference between transaction prices and price implied by underlying supply and demand variables in the derived demand model (5). It also will identify if, for example, forward contract prices or prices discovered in the information treatment have more or less unexplained variation.

The price-level and price-variance models were estimated as weighted random effects models (WREM), given observations in the data set include numerous transactions each week for which some variables have the same values for every transaction within each week. Anderson et al. (1998) and Ward et al. (1999) use the same procedure for estimating econometric models using data from the FCMS. These models correct for two related forms of dependence in the error term. The first source of dependence comes from market agents having common information each week of trading while negotiating prices. For example, all market participants

receive the same previous week's boxed beef price quote before a week of trading. Thus, errors associated with the transaction prices for a given week are not independent. The second source is there are periods in the simulation where bargaining power varies systematically between feedlots and packers across trading weeks (Ward et al., 1999). For example, if a specific transaction price for a given week is high–relative to all the explanatory variables–then all transaction prices will likely be high for that week. This is due to inertia in market dynamics that is readily observable. There are also fixed effects that are included in the models for each replication. Fixed effects are also normalized to zero.

The price-variance model uses the residuals from the WREM price-level model for the dependent variable $\ln(e_{it}^2)$. The price-variance model is estimated with the random and fixed effects described above. Predicted values of the price-variance model are used to further correct heteroskedasticity in the price-level model. Last, the price-level model and the price-variance model were iteratively re-estimated until convergence. Residuals from the price-level model are used to construct the dependent variable in the WREM of the price-variance model and predicted values from the price-variance model are used as weights in the WREM of price levels.

Production efficiency is measured by weight deviations from the optimal market weight for fed cattle of 1,150 pounds. This is the third model. Fixed production technology is used to simulate cattle growth, and 1,150 pounds represents the low-cost weight in the FCMS. An ordered-logit model with the absolute value of deviations from 1,150 pounds as the dependent variable in the model measures production efficiency. The dependent variable is a categorical variable with a value of 0, 1, or 2, representing the 0, 25, and 50-pound weight deviations from the optimum weight of 1,150 pounds.[6] These are the only weight deviations. The weight-

deviation model is specified as:

$$(7) \quad WTV_{it} = \gamma_o + \gamma_1 BBP_{t-1} + \gamma_2 FMP_{t-1} + \gamma_3 TVOL_{t-1} + \gamma_4 TINV_{t-1} + \gamma_5 PPL_t + \gamma_6 FDSZ_{it} + \gamma_7 PKSZ_{it} + \gamma_8 FWD_{it} + \gamma_9 INFO_{it} + \gamma_{10} INFO \times FWD_{it} + \mu_{it}$$

where WTV_{it} is the categorical weight-deviation variable. As with the prior two models, we are interested in the supply and demand variables that explain deviations from optimal marketing. The variables of specific interest are the forward contracting, information, and interaction term of these two dummy variables. The model will determine if the additional information on the volume of forward contracts and the terms of trade of these arrangements provided in the information treatment improves production efficiency.

Results

The boxed beef price for each trading week and each replication is presented in figure 2. Replications 1-5 are student participants and 6-10 are industry participants. The market-ready inventory and volume of marketings are presented in figures 3 and 4. There is one measure of each of these three variables for each trading week. The average cash market transaction price for each trading week and each replication is presented in figure 5. There are an average of 38 transactions each trading week with 25% of those being forward contracts, so the average cash transactions price is the summary statistic for those transactions. The changing market conditions over the simulation– increasing and then decreasing cattle numbers and the opposite for prices– are observed in each figure. The similarity across all replications and between the student replications and industry replications is also seen. These figures provide evidence that our experimental design coupled with the abstraction and control in the FCMS has created similar behavior across the replications and industry participants in general.

Descriptive statistics for selected variables and for the two information treatments are reported in table 1. It is evident that boxed beef, futures, and average fed cattle prices are all slightly lower in the forward contract information treatment than in the no information treatment. The transaction prices are significantly lower. Transaction weights between the treatments are significantly different at the 10% level. The potential profit or loss variable (PPL) between the two treatments also is slightly lower with information but not significantly lower. It is noteworthy that more forward contracting takes place in the replications for which information on forward contracting is provided. The overall mean of the FWD dummy variable is 25%. Thus, 25% of the transactions are forward contracts. The mean of the FWD dummy variable is 22% during replications with no information on forward contracting and is 29% during replications with forward contracting, and the difference is significant. For several of the replications with forward contracting information, the spot market all but disappeared for portions of the second day of the two day experiment. Differences and tendencies are analyzed in more detail through the econometric models.

Estimated models and associated impacts are reported in tables 2 through 4. Results associated with the economic variables within the models that do not deal with forward contracting or forward contract information are discussed first. We do this so that these results can be compared to other FCMS research and research using real-world data. The results of these economic variables provide context and support for the price-level, price-variance, and weight-deviation models. We argue that if the results from these supply and demand variables are reasonable, then the information variables should isolate the impacts of forward contract information provision. After discussing the comparison of those economic variables across the

models, the variables related to the provision of forward contracting information are discussed along with variables that examine forward contract transactions relative to the spot transactions.

Price-Level Model

The price-level model results are generally consistent with a priori expectations (see table 2). The lagged boxed beef price coefficient is positive and significant in explaining transactions price level. The same also is true for the lagged futures market price coefficient. The total slaughter and total market-ready inventory variables lagged show negative and significant relationships with transaction price. Fed cattle prices are in part derived from the demand for boxed beef and are impacted by fed cattle prices discovered in the forward-looking futures market. Transaction prices also are influenced by slaughter volume and the volume of market-ready inventories, holding constant boxed beef and futures price levels. The potential profit coefficient exhibits a negative sign–the greater the profit potential the less of that profit is captured by the feedlots–it is significantly different from zero at the 10% level.

The model R^2 is 77.5%, and the fixed effects variables contribute less than 5%. The random effects result in larger standard errors on model coefficients–mainly those variables that are the same for each transaction within each trading week. These variables are the boxed beef prices, futures price, market-ready inventory, and marketings volume. The fixed effects account for mean differences in price unique to the replication. For example, in figure 5, the average transaction price is the lowest for replication 2 and is the highest for replication 9. However, removing these two replications from the sample does not qualitatively change the model results. The mean differences are accounted for by the fixed effects parameters.

Larger packers paid higher prices, and larger feedlots received higher prices. Within the

FCMS and similar to naturally occurring data, larger packers have a processing cost advantage over smaller packers and pass some of that to feedlots in discovered transaction prices to secure the larger volumes needed. Larger feedlots appear to be able to capture higher prices. They have more cattle available for sale in a given trading week and appear to be able to capture a portion of the saved transactions costs–or in other words, there may be volume premiums. This result is not consistent with the bilateral negotiation model. Larger feedlots have more advance-production risk, but the bilateral negotiation model does not consider transactions costs.

The general results (not including forward contract information) within the model are consistent with past results from the FCMS (see Anderson et al. 1998; Koontz et al. 1995a and b; Ward 2005; and Ward et al. 1996 and 1999) and are consistent with similar models using real-world transaction data (see Ward, Koontz, and Schroeder 1998; and Schroeder et al. 1993).

Price-Variance Model

A priori expectations for the price-variance model are less clear when compared to the price-level model. Results for the economic variables in the price-variance model indicate that higher boxed beef prices are consistent with less unexplained variation in transaction prices (table 2). This suggests that when the market for the derived product is higher, there is less uncertainty in the transaction price. Higher beef prices create a more stable negotiation environment for fed cattle. There are no other variables, outside forward contracting and the information experiment, that are significant.

The model R^2 is 9.4%, and the fixed effects are important. There are replications in both the student and industry groups in which price dispersion is relatively high. As with the price-level model, the random effects reduces statistical significance of many variables.

There is an interesting lack of results in the price-variance model. Larger feedlots and larger packers pay and receive higher prices, but there is no evidence of increased risk. Increased risk with the large feedlots would be consistent with the bilateral negotiation model. There are also no clear price risk incentives to use a marketing method such as forward contracting where advance-production risks are mitigated. However, as will be discussed later, the provision of information does have a strong impact on price dispersion.

Weight-Deviations Model

Results from the weight-deviation model suggest that many market variables impact optimal marketing (table 3). The model coefficients, p-values, and marginal effects elasticities for the continuous independent variables are presented in table 3. Coefficients associated with boxed beef prices, futures prices, slaughter volume, market-ready inventories, potential profits, and firm sizes relative to the largest firm are all statistically significant. Higher futures prices, larger slaughter volumes, and greater potential industry profits are all consistent with more cattle being marketed at optimal weights. Higher boxed beef prices and larger market-ready inventories are consistent with increased non-optimal marketings.

These results, with the exception of higher boxed beef prices, suggest market agents bargain more aggressively when the market conditions have deteriorated and when total profits in the system are lower. Lower futures prices, increased market-ready inventories, smaller volumes marketed, and lower potential profits are all indicative of difficult market conditions. The behavior during these periods creates failed trades and production inefficiencies.

Both larger packers and feedlots are more likely to transact cattle at optimal weights. Marketing cattle at optimal weights appears to be a strategy followed by larger feedlots. Further,

packers actually make higher profits on non-optimal weight cattle, holding transaction price constant, because there are more pounds of meat to sell per head. The results suggest that larger packers are not able to secure pens of larger animals. Non-optimal marketings appear to be most persistent with smaller feedlots and smaller packers. These firms also are receiving and paying lower prices. Thus, there is clearly different behavior between large and small firms.

Forward Contract and Information Impacts

In this section, we report the results associated with the FWD and INFO variables in all of the models. All, or some combination, of the coefficients associated with the INFO and FWD variables are significantly different from zero in all three of the models (tables 2 and 3). The price impacts, elasticities associated with the price impacts, elasticities associated with price dispersion, and marginal effects from the ordered logit model are all reported in table 4. The reference point for measuring the impacts is a spot market transaction price without forward contract information provided. The FWD, INFO, and interaction dummy variables allow examination of forward contract prices relative to spot market prices with and without information on forward contract–like that provided by MPR legislation.

The forward contract transactions are significantly lower than spot market transactions when no information on forward contracts is provided. Forward contract transaction prices are $0.3124/cwt or 0.40% lower than spot prices without the information (table 4). This result is statistically significant and consistent with research from naturally occurring data (Ward, Koontz, and Schroeder 1998; Albæk, Møllgaard, and Overgaard 1997). Likewise, our results are consistent with those reported by Krogmeier et al. (1997), who found forward prices to be lower than spot market prices in an experimental market. This result likely demonstrates the average

risk premium that sellers are willing to part with in order to secure a forward sale and is consistent with reducing advance-production risk in the bilateral negotiation model.

Perhaps most interesting is the negative impact the new information has on spot transaction prices and forward contract transactions prices. With forward contract information, spot prices are $1.3624/cwt (or 1.75%) lower than spot transaction prices without the new information, and forward contract transactions are $0.7123/cwt (or 0.91%) lower than forward contract transaction prices without the new information. However, the impact on forward contract transactions is not significantly different from zero at the 10% level.

Three dummy variable coefficients can be used to construct a complete enumeration of the impacts of providing forward contract information. The relevant coefficients are added and standard errors account for covariance. The impact on spot prices when moving from a market with no forward contract information to a market with institutions reporting forward contract information are the results of the coefficient for the INFO dummy variable (i.e., -1.3624). The impact on forward contract prices when moving from no forward contract information to a market with forward contract information is that forward contract prices are $0.3999/cwt (or 0.51%) lower in the information treatment. This result is not statistically significant. Marketing fed cattle through a forward contract instead of the spot market will result in $0.6501/cwt (or 0.83%) higher prices with the provision of forward contract information.

These results support intuitions from the bilateral negotiation model. The results are indicative of decreased information risks for both the buyer and seller, which appear to increase the overall negotiation advantage for the buyer relative to the seller. Buyers have improved knowledge about the quantities forward contracted, and this reduces risks associated with

securing volume for the packing plant for the current or upcoming periods. The forward price and quantity information reduces risks for the seller associated with the competitiveness of forward contracting offers. This leaves the seller with the risk of not covering costs associated with production (i.e., advance-production risk) during spot price negotiation. Thus, as these information costs are reduced, coupled with the buyer having a bargaining advantage over the seller due to advance-production risk, the forward contract market becomes more attractive and sellers are willing to accept a lower forward price to reduce their advance-production risk that exists in spot trading. During spot negotiation the buyer knows the quantity of cattle that will be delivered during that trading period through the information presented on forward contracts. This information clearly puts the buyer at an advantage when negotiating spot price which is reflected in a lower spot price relative to the forward price when information is presented.

With forward contract information, it is expected that price dispersion–or unexplained variation in transaction prices–will decrease. The results from the price-variance model provide evidence supporting this hypothesis (table 2). The coefficient on the information variable has the expected negative sign but is not significantly different from zero. The coefficient on the interaction between information and forward contract is significantly different from zero and indicates a negative impact on price. This suggests that price variance, at least for forward contract prices, is reduced with information. The results also suggest that forward contract transactions have higher dispersion than spot transactions and it is statistically significant.

Table 4 presents an assessment of the impacts of forward contract information on dispersion. Elasticities are calculated using methods of Halvorsen and Palmquist (1980) and significance is examined with Wald tests. P-values of the tests are reported. Forward contract

prices are 33.5% more disperse than spot market transactions without the added forward contract information. Forward contract prices are discovered at least two weeks prior to delivery, and it is likely that this time dimension, as well as different expectations of price changes, creates this dispersion. Spot price dispersion shrinks 0.22% with the provision of information on forward contracts. This forward market does not contribute to price discovery in the spot market. Forward contract prices are much less disperse with the reported information. With information, forward contract prices are 22.36% less disperse than spot prices without the forward contract information. The combined effect is that forward contract prices are 55.86% less disperse with the new information. Further, forward contract prices are 22.14% less disperse than spot market prices in the information treatment.

Thus, forward contract transactions receive higher prices and are less risky than spot market transactions when forward contract information is provided. These two findings are important results of this work. Provision of forward contracting information will potentially decrease the use of spot markets. This was observed in several of the experiments. Participants simply used forward contracts more frequently when information about the forward contract market was provided. Moreover, there were time periods during almost every INFO replication in which 75-80% of the market volume was through forward contracts.[7]

The weight-deviation model indicates that the forward contract variable coefficient is statistically significant. The information variable is not significantly different from zero, but there is a significant interaction between INFO and FWD (table 3). The marginal effects reported in table 4 indicate that forward contract transactions are more likely to be marketed at optimal weights than spot market transactions without the new information. Forward contracts

are 16.2% more likely to be traded at the optimal weight and 22.05% less likely to be traded at 50 pounds away from the optimal weight (table 4). With the added forward contract information we see that spot market transactions are more likely to be marketed at optimal weights (+1.39%). However, this impact is not statistically significant. With the added forward contract information, forward contracts are 32.67% more likely to be sold at the optimal weight and 49.05% less likely to be sold at 50 pounds from the optimal weight. The combined effect is that forward contract cattle are 16.47% more likely to be marketed at the optimal weight and 26.99% less likely to be marketed at 50 pounds from the optimal with the new information. Further, forward contract cattle are 31.29% more likely to be marketed optimally and 47.31% less likely to be marketed 50 pounds from optimal weight when compared to spot market transactions with forward contract information provided. The increased information changes behavior regarding the timing of marketing. The seller has less risk associated with selling in the forward market than in the spot market when information is present. Thus, sellers are more likely to sell at weights that are optimal in the forward market, given this information, and avoid advance-production risk when selling cattle at non-optimal weights in the spot market.

A hypothesized result is that production efficiency should be improved by the forward contract information. It is expected that the timing of sales will be adjusted so that the number of cattle sold away from the optimal weight will be reduced. The experimental results strongly suggest this behavior. The added information has little impact on spot market transaction marketing, but the information makes forward transactions more efficient (relative to without the information) and makes forward transactions a more efficient means of selling cattle (relative to the cash market). The information creates means for capturing production efficiency by

decreasing non-optimal marketings in the contract market. Overall, these results point toward a potential improvement in production efficiency in the forward market, but perhaps not in the spot market, with the new information.

Summary and Conclusions

Policy makers will continue to seek regulatory solutions designed to improve the competitive position of sellers in agricultural markets. For example, the intent of mandatory price reporting was to provide forward contract information to the public and thereby increase competition (U.S. Senate, 1999; USDA AMS, n.d.). This forward contract information represents marketing intentions and terms of trade information that was previously unavailable to all agents in the fed cattle market. An experiment using the FCMS was designed to assess the potential impacts of forward contract information on price discovery and production efficiency for fed cattle.

Econometric analyses of the experimental data suggest that the addition of publicly reported forward contract information will reduce price dispersion and reduce price levels. Results indicate that improved production efficiency in the forward contract market but perhaps not in the spot market. These results may not be popular among sellers in the market place. Forward contract information in this experiment seems to be more advantageous for buyers than for sellers when negotiating price.

The theoretical work by Azzam (2003) is not supported by our empirical results. Our work supports the conclusions of Grunewald, Schroeder, and Ward (2004) and Wachenheim and DeVuyst (2001). Why the divergence? First, trading institutions within which price is discovered (auction versus private negotiation) and delivery method (spot versus forward)

affects market outcomes (see Menkhaus, Phillips, and Bastian, 2003). Second, given the information risks coupled with advance-production risk, the bargaining advantage shifts to buyers in private negotiation when forward contract information is provided. Menkhaus, Yakunina, and Phillips (2001) results provide an indication of this and support our results.

Theory indicates that the impacts of increased information reduces risks for both buyer and seller, but it leaves us with an indeterminate prediction regarding transaction price in bilateral negotiation. Our results indicate that price level is reduced with forward contract information, which is counter to traditional thinking that more information is preferred to less in agricultural markets. Ultimately, the information regarding quantity of forward contracted cattle gives buyers an advantage when sellers face advance production risk as they negotiate price in our simulated bilateral trading institution.

Another important result of this research is that it illustrates the complexity and interaction of behaviors in a relatively simple market. Changing the information set in the one market, the forward contract market, impacts behavior in that market and the related cash market. The behavior change is substantial.

Conventional wisdom in agricultural market analysis is dominated by the purely competitive market structure paradigm. Theory and past research regarding added information in markets that closely resemble this paradigm would typically lead analysts to an a priori prediction of price enhancement for sellers given an expansion of publicly reported transactions. Perhaps the most important implication of this research is that as trading institutions continue to change in agricultural markets, policy makers and analysts can no longer make or accept blanket policy prescriptions regarding transparency without an investigation tailored to the targeted

market and the institution within which prices are discovered.

Footnotes

1. Livestock Mandatory Price Reporting went into effect in April 2001, and a termination date of December 2004 was set in the legislation. In December 2004, the legislation termination date was extended until September 2005 and as of that date, the legislation has expired. However, the USDA Agricultural Marketing Service continues to operate the reporting program based on voluntary participation. The reporting program is largely computerized and mechanical.

2. Students were paid a two-part rate to participate. There was a flat rate for participating and a variable rate that depended on performance. Participants were rewarded for profitable play and penalized for unprofitable play. Students were paid $50 per person to participate and received $1 per average dollar profit on all pens of cattle bought or sold over the two day replication. Likewise, teams were penalized $1 per average dollar loss on all pens of cattle bought or sold up to the $50 participation payment. At the end of the two day replication, each feedlot and meatpacking team had an average profit/loss per head. If it was a loss for the team then their participant pay was docked. If their team experienced an average loss of $15 per head, then individuals on that team were paid $35 per person. If the team experienced an average profit of $20 per head, then individuals on that team were paid $70 per person. Average payments were close to $50. Minimum payments were approximately 60% of $50 and maximum payments were approximately 140%. Student participants were never paid a zero amount.

3. Pens of cattle that are not sold during the week the pen is 1,200 pounds are automatically sold by the FCMS software at the beginning of the following trading period to a “fifth packer” that is

internal to the software at a large predetermined discount to the spot market price. This is not a transaction between two experiment participants, it occurs very rarely, it is necessary for internal consistency of the market, and these pens are ignored in transaction models. However, the meat volume does stay within the market and impacts the boxed beef price.

4. There is a nearby contract, an intermediate contract that expires 8 weeks after the nearby, and a distant contract that expires 16 weeks after the nearby. When the nearby contract expires, the next distant contract becomes available for trade. The distant contract always expires after cattle placed in the current week enter the showlist. Thus, the existence of three contracts mirrors the real world, provide depth in price discovery information, and complete coverage for risk management.

5. An example alternative would have been to use a split design where participants in each replication trade under both treatments- no information on forward contracts and provision of information on contracts. However, such a design could have potential drawbacks relating to reduced control and the possibility of agent behavior being impacted by expectations being formed from a previous information treatment when switching to the new information treatment within each replication.

6. There are very few transactions below the optimal weight of 1,150 pounds. If below optimal weights are made categories in the multinomial logit model, then the model does not converge. Thus, the -25 pounds group is combined with +25 pounds and -50 pounds with +50 pounds.

Most importantly, there is no qualitative impact on the reported results model if all the under-optimal-weight transactions are dropped from the sample. The results are robust to the assumption.

7. Forward contracting appeared to break down when spot market prices turned out to be quite different from forward contract prices for a series of delivery weeks. This was most often caused by changing supply scenarios, large supplies or small supplies, as demand was stable.

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Table 1. Descriptive Statistics for Model Variables.

	Full Sample		No Forward Contract Information		Forward Contract Information	
Variables	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Boxed Beef Price ($/cwt.)	123.2224	7.7252	123.3435	7.8676	123.0949	7.5709
Cattle Futures Market Price ($/cwt.)	78.7521	4.2181	78.8906	4.2504	78.6063	4.1794
Slaughter Volume (# pens)	37.8046	6.7954	37.7500	7.1104	37.8621	6.4472
Market-Ready Cattle Inventory (# pens)	123.0262	20.5494	121.4974	19.3158	124.6360	21.6579
Industry Potential Profit or Loss ($/cwt.)	1.3022	4.7363	1.4007	4.7608	1.1984	4.7086
Feedlot Size (% of smallest)	1.1550	0.0924	1.1550	0.0926	1.1551	0.0923
Packer Size (% of smallest)	1.2787	0.1952	1.2740	0.1957	1.2870	0.1946
Forward Contract Dummy	0.2513	0.4338	0.2172**	0.4124	0.2873**	0.4525
Information Dummy	0.4871	0.4999	0.0	0.0	1.0	1.0
Transaction Cattle Price ($/cwt.)	78.0198	5.5298	78.9295**	5.8310	77.0619**	5.0192
Transaction Cattle Weight (Pounds)	1156.2157	17.1071	1155.4367*	16.3303	1157.0360*	17.8532
Number of Transactions	13,305		6,824		6,481	

Note: T-tests were used to compare means of the two information treatments. ** denotes the means are significantly different at the 5% level and * denotes the 10% level.

Table 2. Estimated Coefficients for the Price-Level and Price-Variance Models.

	Price-Level		Price Variance	
Variables	Coeff.	P-Value	Coeff.	P-Value
Boxed Beef Price (BBP_{t-1})	0.3374	0.0001	-0.0513	0.0490
Futures Market Price (FMP_{t-1})	0.4015	0.0001	0.0431	0.2119
Slaughter Volume ($TVOL_{t-1}$)	-0.0823	0.0001	0.0034	0.7969
Market-Ready Cattle Inventory ($TINV_{t-1}$)	-0.0496	0.0001	0.0058	0.4328
Potential Profit or Loss (PPL_t)	-0.0805	0.0842	0.0340	0.3441
Feedlot Size ($FDSZ_{it}$)	0.1426	0.0428	0.0656	0.6909
Packer Size ($PKSZ_{it}$)	0.4293	0.0001	0.0501	0.5169
Forward Contract Dummy (FWD_{it})	-0.3124	0.0001	0.2889	0.0001
Information Dummy ($INFO_{it}$)	-1.3624	0.0053	-0.0022	0.9953
$INFO \times FWD_{it}$	0.9625	0.0001	-0.5398	0.0001
Constant	10.5306	0.0001	7.2187	0.0001
R-Squared	0.7747		0.0935	
Model Significance	0.0001		0.0001	

Table 3. Estimated Coefficients and Selected Marginal Effects Elasticities for the Weight-deviation Model.

	Model		Marginal Effects Elasticities		
Variables	Coeff.	P-Value	Optimal	25	50
Boxed Beef Price (BBP_{t-1})	0.0304	0.0073	-0.7494	0.6028	0.1466
Futures Market Price (FMP_{t-1})	-0.0399	0.0299	0.6284	-0.5055	-0.1229
Slaughter Volume ($TVOL_{t-1}$)	-0.0320	0.0001	0.2420	-0.1947	-0.0473
Market-Ready Inventory ($TINV_{t-1}$)	0.0242	0.0001	-0.5957	0.4792	0.1165
Potential Profit or Loss (PPL_t)	-0.0892	0.0001	0.0232	-0.0187	-0.0045
Feedlot Size ($FDSZ_{it}$)	-1.5227	0.0001	0.3516	-0.2828	-0.0688
Packer Size ($PKSZ_{it}$)	-0.8417	0.0001	0.2152	-0.1731	-0.0421
Forward Contract Dummy (FWD_{it})	-0.9081	0.0001			
Information Dummy ($INFO_{it}$)	-0.0694	0.7853			
$INFO \times FWD_{it}$	-1.4459	0.0001			
Mu	2.2726	0.0001			
Log Likelihood Ratio Test	575.62	0.0001			

Table 4. Price Impacts, Elasticities, and Marginal Effects from the Price-Level, Price-Variance, and Weight-deviation Models Explaining the Impact of Reporting Forward Contract Information.

	Price-Level Model Impact ($/cwt)	Price-Level Model Elasticity (%)	Price-Variance Model Elasticity (%)	Weight (optimal) (%)	Weight (±25 lbs.) (%)	Weight (±50 lbs.) (%)
Spot Transactions w/o Information	Base	Base	Base	Base	Base	Base
Forward Transactions w/o Information (E.g., β_8)	-0.3124 (0.0001)	-0.0040	0.3350 (0.0001)	0.1620	0.0585	-0.2205
Spot Transactions w/ Information (E.g., β_9)	-1.3624 (0.0053)	-0.0175	-0.0022 (0.9952)	0.0139	0.0035	-0.0173
Forward Transactions w/ Information (E.g., $\beta_8 + \beta_9 + \beta_{10}$)	-0.7123 (0.1468)	-0.0091	-0.2236 (0.4616)	0.3267	0.1637	-0.4905
Spot Transactions from w/o to w/ Information (E.g., β_9)	-1.3624 (0.0053)	-0.0175	-0.0022 (0.9952)	0.0139	0.0035	-0.0173
Forward Transactions from w/o to w/ Information (E.g., $\beta_8 + \beta_{10}$)	-0.3999 (0.4161)	-0.0051	-0.5586 (0.0695)	0.1647	0.1053	-0.2699
Spot to Forward Transactions w/ Information (E.g., $\beta_9 + \beta_{10}$)	0.6501 (0.0001)	0.0083	-0.2214 (0.0010)	0.3129	0.1603	-0.4731

Note: Weight column percentages denote the probability of observing the weight category (optimal, ±25 lbs, or ±50 lbs) under the different regimes and the sum of the row totals to zero. P-Values are reported in parentheses.

Figure 1. Organization of FCMS Trading Structure.

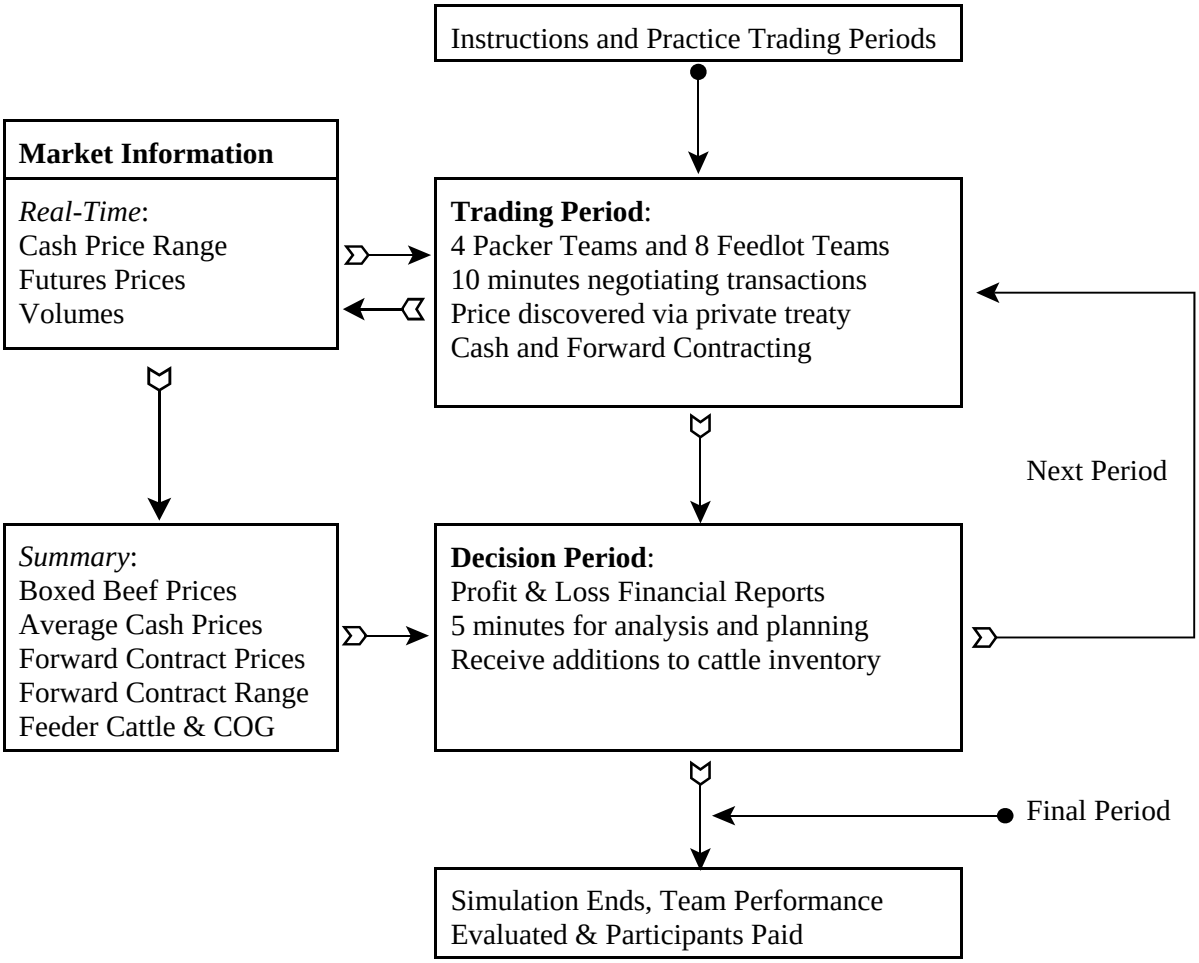

Figure 2: Boxed Beef Prices Across the Ten Replications.

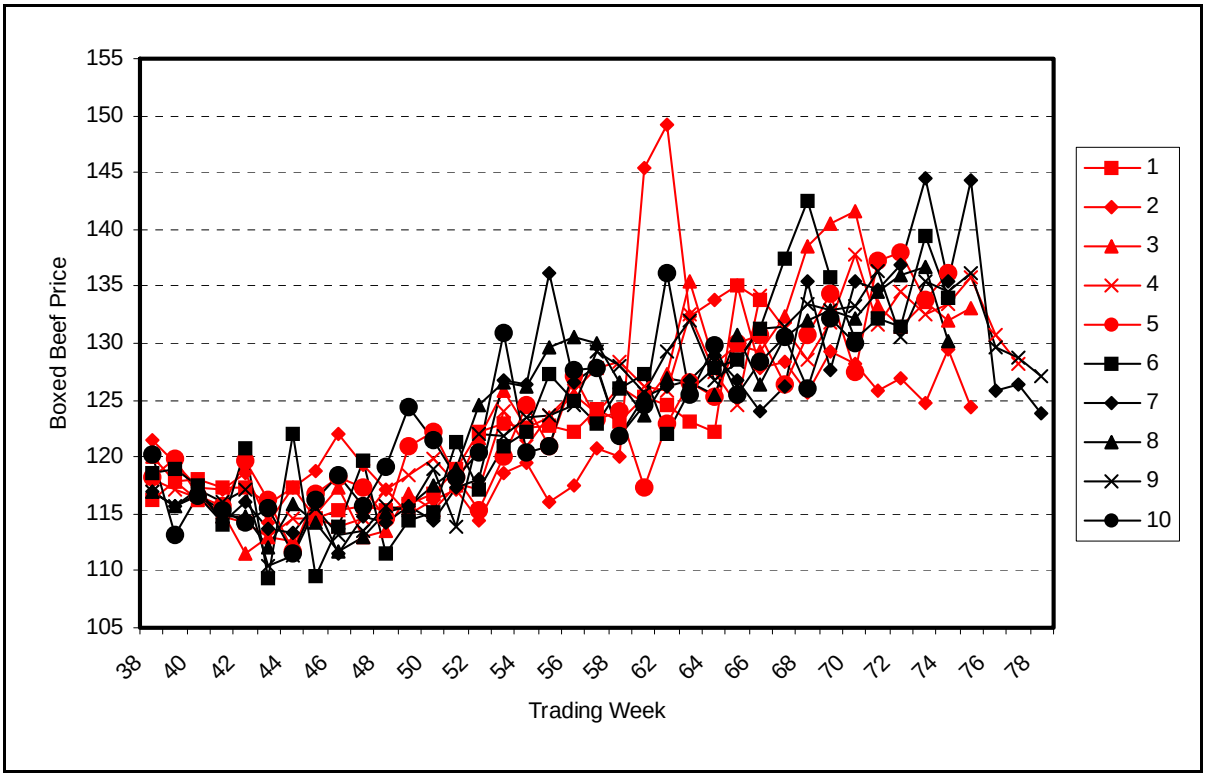

Figure 3: Market-Ready Cattle Inventories Across the Ten Replications.

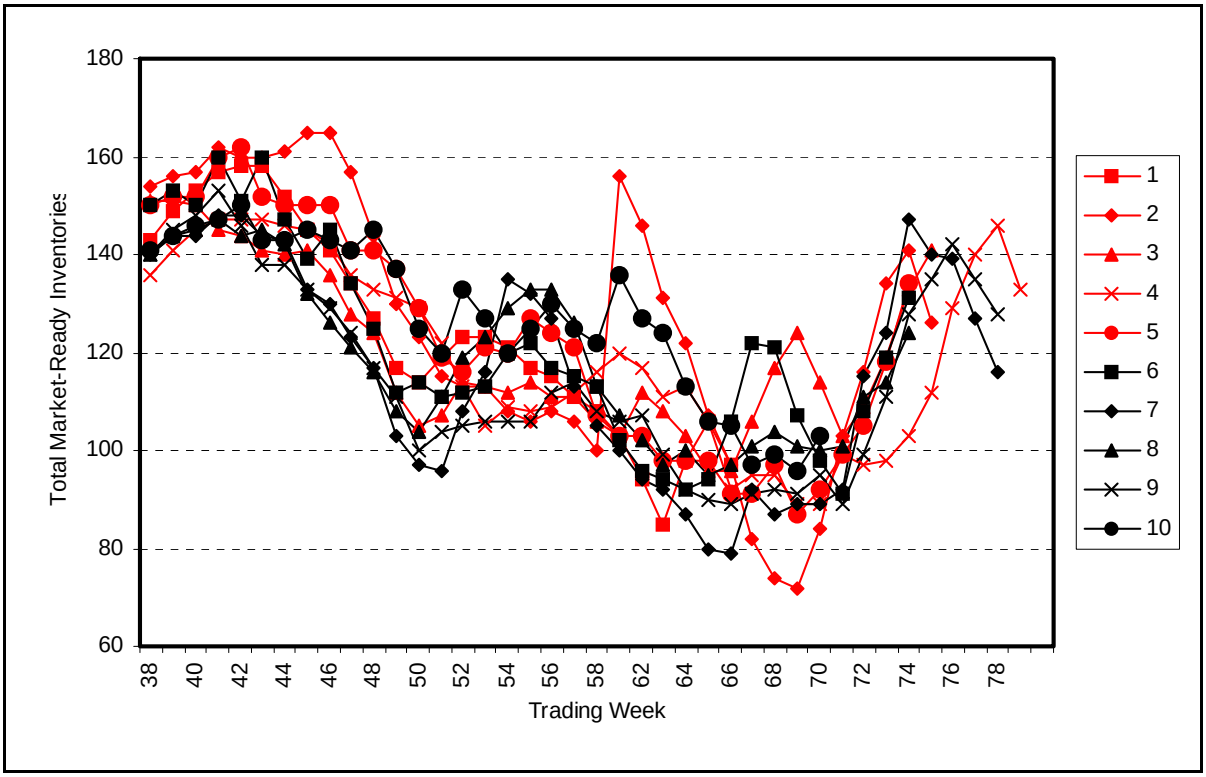

Figure 4: Slaughter Volumes Across the Ten Replications.

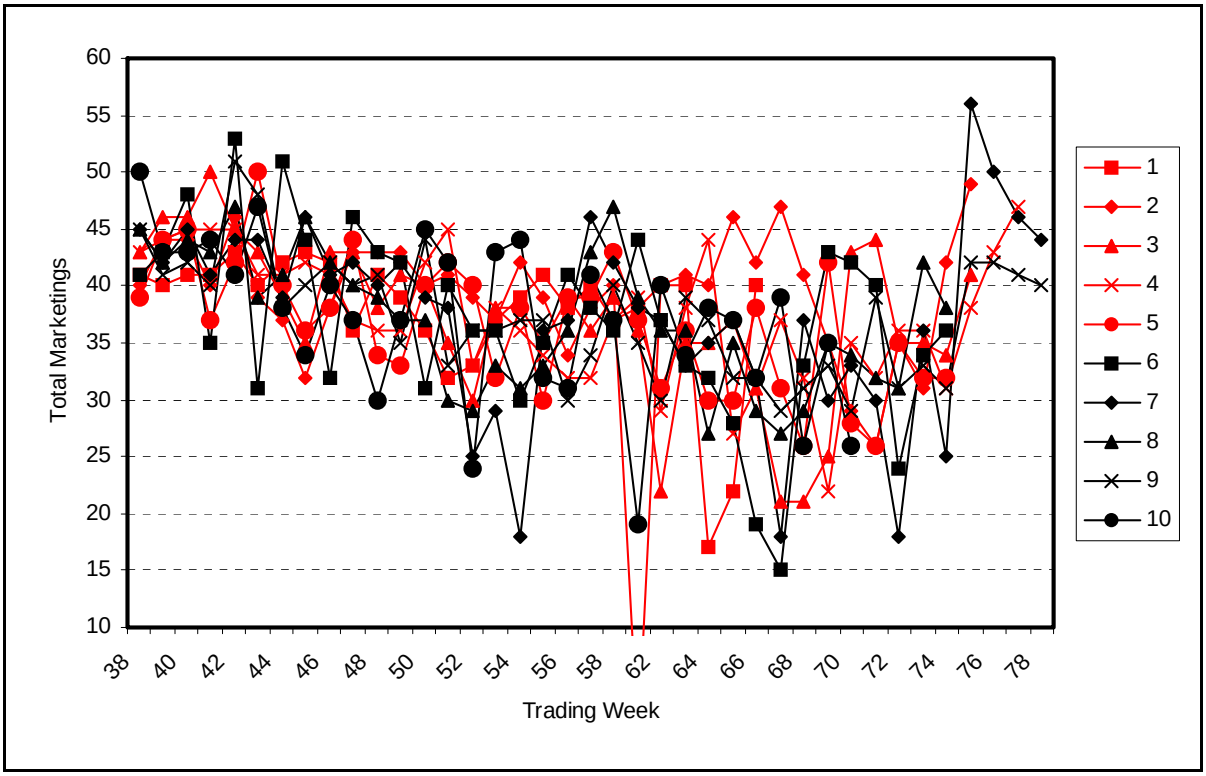

Figure 5: Average Cash Cattle Transaction Prices Across the Ten Replications.