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MARKETING AGREEMENT IMPACTS IN AN EXPERIMENTAL MARKET FOR FED CATTLE

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Marketing agreements between meatpacking and cattle feeding firms have created concerns about their effects on fed cattle prices. Profit-sharing marketing agreements were imposed onto a simulated fed cattle market. Price level and variability differences with and without agreements, between agreement participants and nonparticipants, during agreement and nonagreement periods, and between participants receiving and not receiving a monetary incentive were evaluated. Prices and variability for nonagreement cattle were higher during the agreement periods. Marketing agreement participants realized lower, less variable prices than nonparticipating firms. Monetary incentives did not affect price levels but increased price variability.

Key words: captive supplies, cattle feeding, fed cattle, marketing agreements, meatpacking, prices.

Procurement of fed cattle by packers through non-cash-price procurement methods has increased in importance during the past decade and raised concerns among cattle producers, congressional representatives, and government agencies. These concerns led to a congressionally mandated study (USDA, Grain Inspection, Packers and Stockyards Program), one part of which focused on impacts from non-cash-price procurement methods. However, concerns regarding packer behavior and price impacts persist (USDA, Agricultural Marketing Service).

Industrial organization theory argues that price is dependent on buyer and seller behavior, or conduct, within a given market structure. Two lines of research in agricultural economics have measured the impacts from an abrupt change in market structure and buyer-seller behavior within the livestock-meat subsector. One line of work estimated price impacts when a buyer exited a market via a slaughter plant closing (Love and Shuffett; Ward 1983; Hayenga, Dieter, and Montoya). Prices in the markets studied declined relative to comparison markets when a buyer closed a slaughter plant in two of the three studies (Love and Shuffett; Ward 1983). However, Hayenga, Deiter, and Montoya found no immediate price decline in any of the six markets studied and only brief periods of significant price declines in four of six markets.

A second line of research focused on price impacts when a buyer or buyers entered a market, either because of a change in marketing method (Ward 1984; Rhodus, Baldwin, and Henderson; Bailey and Peterson) or when a plant opened (Hayenga, Dieter, and Montoya). Price increases were observed in all four studies when number of buyers increased. Hayenga, Dieter, and Montoya found that prices increased in one of two markets when hog slaughter plants reopened, but prices did not change significantly when the other plant reopened.

Price effects in the above studies result from the interaction of supply-demand shifts and market structure-behavior changes. There are numerous examples in the fed cattle market over the past two decades of abrupt changes in the market structure or behavior of buyers and sellers. One highly publicized event occurred in 1988 when one of the largest cattle feeding firms (Cactus Feeders) entered into a marketing agreement with the largest beef-packing firm (IBP). Under the agreement, Cactus Feeders agreed to market up to

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800,000 fed cattle annually from seven feedlots to three IBP plants, or up to 16% of steer and heifer slaughter in Texas in 1988. The immediate effect was a leftward shift or reduction in the available supply of fed cattle to other potential packers. There was also a leftward shift in demand by IBP for uncommitted fed cattle, an effect similar to a plant closing. Reducing the supply of available fed cattle led to a change in the distribution of available cattle from feedlots to packers and a potential change in the relative bargaining position of feedlots and packers. Buyers who previously purchased fed cattle from Cactus Feeders had to purchase cattle from other feedlots to keep their plants operating at the same utilization level. Some feedlots which previously sold fed cattle to IBP had to find another buyer. Price effects from the supply-demand shifts have not been estimated.

This type of exclusive marketing agreement became known as one of three captive supply procurement methods, along with forward contracting and packer feeding. In each case, fed cattle are purchased two or more weeks prior to slaughter and in advance of fed cattle purchased in the cash market. Studies to date which have attempted to measure the effects from captive supplies have focused on measuring the price impacts from varying levels of captive supplies.

Elam found that increased forward contract deliveries were associated with lower monthly average fed cattle prices in Nebraska, Kansas, Colorado, and Texas over the period October 1988 to May 1991. Prices across the four states were \$0.03–\$0.09/cwt lower for each additional 10,000 head of forward contract deliveries. Hayenga and O'Brien compared weekly average fed cattle prices in the same four states over the period October 1988 to December 1989 with reported market prices for other markets. Captive supply deliveries were found to have mixed positive and negative effects, mostly not significant. Schroeder et al. (1993) found a negative relationship between captive supply shipments and fed cattle transaction prices over a six-month period from May to November 1990 in southwestern Kansas. Increased forward contract and marketing agreement deliveries resulted in lower prices ranging from \$0.15–\$0.31/cwt. Ward, Koontz, and Schroeder estimated impacts from captive supply deliveries on transaction prices throughout the United States from April 1992 to April 1993. Results were generally negative. A 1% increase in deliveries led to a decline in cash market prices of \$0.05/dressed cwt for forward contracts, a decline of \$0.36 for marketing agreements, and no significant effect for packer-fed cattle.

No previous studies have examined the effects on transaction prices from an abrupt market change similar to the Cactus Feeders-IBP agreement. One reason for the lack of research is that detailed terms of most exclusive marketing agreements are seldom disclosed publicly, and access to data needed to estimate impacts of these agreements on cash market prices is limited. The approach taken in this study was to use econometric methods with experimental data generated by participants of the Fed Cattle Market Simulator (FCMS). This study addresses the following questions: What price effects occurred when a significant percentage of the fed cattle supply normally available to all buyers was contractually obligated to a single packer? What is the price effect, on both level and variability, from a leftward shift in both supply and demand? What is the effect on participants in the agreement and/or on those who do not participate?

The objective of this article is to report the impacts on transaction prices from imposing an exclusive marketing agreement on the simulated fed cattle market. This is the first effort to measure marketing agreement impacts as an abrupt change or event in the market structure and behavior of the fed cattle market, paralleling previous work examining price impacts from plant closings and openings and from changes in livestock marketing methods.

Fed Cattle Market Simulator Structure

The FCMS creates a market for fed cattle in which participants role-play as feedlot marketing managers and meatpacking procurement managers (Ward et al.). Eight participating feedlot teams and four participating meatpacking teams trade cattle and generate fed cattle transaction records. Feedlot teams market fed cattle from their feedlot when cattle reach acceptable finish weights. Meatpacking teams purchase fed cattle for processing into boxed beef. Participants for this study were Oklahoma State University students enrolled in an agricultural economics course which met weekly for ninety minutes during the spring 1995 semester. Students, primarily juniors and seniors majoring in agricultural economics, animal science, and ag-

ricultural education, were divided into twelve four-person teams.

The time reference and trading periods in the simulated market are weeks. During each seven-minute trading period or week, feedlots and meatpackers negotiate prices and transactions. About forty transactions occur per trading period on average. Participants role-playing as meatpacking procurement managers approach feedlots to purchase cattle. Each feedlot has a visible array of paper pens of cattle with each sheet of paper representing 100 animals on a show list, that is, cattle available for sale. Prices are negotiated and sales occur for the range of available weights of show-list cattle, from 1,100 to 1,200 pounds in 25-pound increments. Cattle in the simulated market grow 25 pounds per week and must be processed into boxed beef in the five-week marketing window. However, cattle can be sold anytime during the five-week period. Cattle sold in the current week for delivery in the current or following week are treated as cash market transactions. Cattle to be delivered two or more weeks in the future are recorded as contract transactions, that is, they follow the reporting protocol used by Agricultural Marketing Service (AMS)–U.S. Department of Agriculture (USDA) market reporters.

Continuous market information is provided during the trading period on two digital display bars, one which scrolls cash market information (trading volume and high-low price range) and the other which scrolls futures market information (trading volume and current prices for three active futures contracts). Current market information parallels within-week or within-day market information available to fed cattle buyers and sellers from AMS-USDA and the Chicago Mercantile Exchange (CME).

Cattle placements in feedlots include periods of larger and smaller supplies, as occur in a cattle inventory cycle. Fed cattle market conditions and resulting prices are driven largely by how effectively participants market and purchase fed cattle. *Cattle on Feed* reports, much like those reported by the USDA's National Agricultural Statistics Service (NASS), are issued every four trading weeks and indicate feeder cattle placements, fed cattle marketings, and cattle on feed, in total and by weight groups. The underlying market structure of the FCMS was intended to reflect the structure which has evolved in the real-world fed cattle market, that is, relatively few large cattle feeding firms and fewer large beefpacking firms.[1] The proportion of feedlots to packers in the FCMS does not match exactly the proportion in the underlying market. Thus, care must be exercised in transferring results directly to the real-world market, since the structure in the experimental market potentially could affect experimental simulation results.

Experimental Design and Data

Experimental simulation with the FCMS integrates business simulation and experimental economics (Ward et al.). As such, it entails components of microeconomic systems that have been identified by experimental economists for laboratory experiments (Smith 1976, 1982, 1994; Plott; Friedman and Sunder). Within a specified market structure and set institutional structure, subjects or participants of experimental simulation studies make decisions that affect performance of their particular firm and the entire market.

The distinction between experimental simulation and experimental economics revolves around the amount of physical control researchers impart on subjects of the experiment. In experimental economics, the experimenter purposefully and directly controls specific variables of the system, thus allowing the experimenter to monitor and focus on selected variables in order to draw conclusions about how those selected variables affect economic behavior and performance (Friedman and Sunder). The purpose of experimental simulation is to evaluate dynamic relationships between many economic variables of a specified market when major components of that market are affected by realistic market changes.[2] With experimental simulation, researchers control relatively few variables, thus allowing economic variables to interact more

[1] The simulated market was designed to be a reasonable model for larger regional fed cattle markets. The "Big 3" packers and one larger independent packer are usually present in these markets. While there are substantially more feedlots than packers in the major cattle feeding regions, many individual feedlots are part of multilot firms. Further, many other feedlots are smaller and at most constitute a competitive fringe. Therefore, it was perceived that the strategic interaction between feedlots and meatpackers involves a relatively small number of players. A two-to-one assumption was used because it balanced structural realism with programming complexities, number of participants, and other modeling constraints.

[2] The distinction has the following ramification. Properly designed experiments in experimental economics can make use of simple statistical methods, usually analysis of variance. Less controlled experiments, as with the FCMS, require econometric modeling.

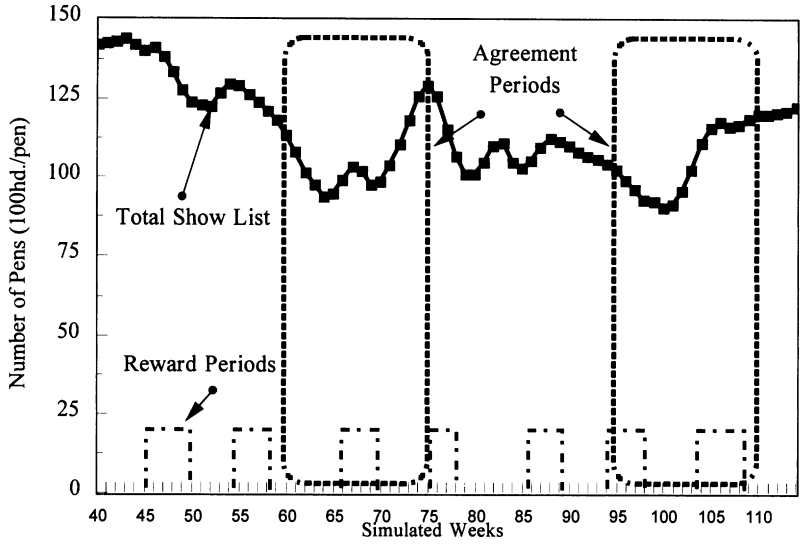

Figure 1. Graphical depiction of experimental design

with one another much like real-world markets (Ward et al.). Participants of the simulated market experience consequences of interrelated decisions they must make regularly.

Data for this research were generated from seventy-five trading weeks of the FCMS. Students began trading in week 21 of the FCMS, a typical start-up week, and traded through week 39 as part of the learning process.[3] During that time, the twelve teams were rotated twice so each student assumed the role both of packing plant manager and feedlot manager. Data collection began in week 40 and ended in week 114. Student teams were rotated in week 76 as a means of replicating the marketing agreement experiment. During weeks 40–75 and 76–114, there were two predetermined sixteen-week periods in which a marketing agreement was imposed between the largest meatpacking firm (packer #4) and the two largest feedlot firms (feedlot #2 and feedlot #5). Figure 1 shows the experimental design along with the supply of fed cattle on the show list during the semester-long simulation. During the marketing agreement periods, packer #4 purchased 76.1% of its fed cattle via the agreement with feedlots #2 and #5. The marketing agreement accounted for 25.8% of transactions during the agreement periods. Thus, the experimental design enabled measuring the effect from an abrupt increase in captive supplies via marketing agreement for the entire market as well as for participating firms.

Agreement firms were informed when the agreement began but not how long it would continue. Nonparticipating firms were informed via a brief announcement, much like a press release, that a marketing agreement had been formed. The agreement terms were explained to the participating firms prior to trading weeks 60 and 96, respectively. Under the agreement, feedlots #2 and #5 marketed all their cattle when they reached 1,150 pounds to packer #4. The 1,150-pound weight class is the least-cost weight at which to market cattle in the FCMS. Packer #4 dealt with feedlots #2 and #5 individually, and participating firms were instructed to negotiate profit-sharing prices. This agreement differed from the Cactus Feeders-IBP agreement and most others found in the fed cattle market. Price in most agreements is based on a formula (Schroeder et al. 1997). Our assumption for the experimental simulation was that industry agreements implicitly entail some degree of profit-sharing between buyers and sellers. Thus, packer #4 and feedlots #2 and #5 were instructed to share information on their break-even prices and profits/losses and negotiate a profit-sharing price each week.

Experimental economists advocate providing monetary incentives to participants (Smith 1976, 1982; Plott; Friedman and Sunder).

[3] Week 21 is the startup week because, in the simulation, an inventory of cattle is constructed through placements of cattle on feed. Placements are controlled parameters. Cattle are placed in week 1 and fed for seventeen weeks to reach marketable weight. The four additional weeks allow sufficient inventory to build on the show list for the market to function.

Therefore, a reward system was designed based on the profitability of firms operated by FCMS participants. Student rewards were based on the profit performance in randomly selected four-to-seven week periods interspersed with four-to-seven week periods of no rewards. Total periods of reward and nonreward were equal over the semester (figure 1). Students were informed at the beginning of each series of trading weeks about when they were and were not being rewarded. The reward structure was designed to meet the sufficient conditions for controlling subject preferences in an economic experiment, that is, nonsatiation or monotonicity, salience, dominance, and privacy (Smith 1976, 1982; Plott; Friedman and Sunder). Specifically, teams were rewarded based on their average profit per head which they monitored on profit and loss statements at the end of each trading week. Students shared a total of $900 at the end of the semester, about $20/participant on average. The distribution of monetary rewards ranged from zero to $36.20/participant.

Data collected for this study consisted of transaction prices with associated information for seventy-five weeks of trading, or 2,770 pens of fed cattle. Each data record consisted of one transaction between one feedlot firm and one meatpacking firm. Data for each transaction included week traded, meatpacker purchasing the cattle, feedlot selling the cattle, weight of cattle traded, transaction price, and type of transaction (cash, forward contract, or marketing agreement). Other data recorded for each trading week included break-even prices for 1,150-pound cattle for each feedlot and the largest meatpacker, boxed beef price, closing nearby futures market price, number of fed cattle marketings, and number of pens of cattle on the show list at the beginning of each trading week.

Models Specified

Previous transaction price models (Ward 1992; Schroeder et al. 1993; Ward et al.; Ward, Koontz, and Schroeder) provided the basis for the models specified in this study.

Transaction Price Model

A transaction price model similar to Ward et al. was specified to estimate how exclusive marketing agreements affected the level of transaction prices. Transaction prices were modeled as a function of boxed beef prices (*BBP*), futures market prices (*LCFMP*), fed cattle marketings (*TM*), total inventory of cattle on the show list (*TSL*), and potential profit/loss to be shared by packers and feeders (*PPL*). Also included were binary dummy variables for the feedlot selling cattle (*DFDLT*) and for the packer buying cattle (*DPKR*). Additional binary variables were included to measure price differences with and without the marketing agreement (*DMA*), for marketing agreement participants and nonparticipants during the marketing agreement periods (*DMAP*), for marketing agreement participants and nonparticipants outside the marketing agreement periods (*DNMP*), and for reward and nonreward periods (*DPAY*). The model specified and estimated was

$$
\begin{aligned}
(1)\quad TPFC_{it} &= \beta_0 + \beta_1 BBP_{t-1} + \beta_2 LCFMP_{t-1} \\
&\quad + \beta_3 TM_{t-1} + \beta_4 TSL_t + \beta_5 PPL_t \\
&\quad + \sum_{j=1}^{8} \beta_{6j} DFDLT_{jit} + \sum_{j=1}^{4} \beta_{7j} DPKR_{jit} \\
&\quad + \sum_{j=1}^{2} \beta_{8j} DMA_{jit} + \sum_{j=1}^{2} \beta_{9j} DMAP_{jit} \\
&\quad + \sum_{j=1}^{2} \beta_{10j} DNMP_{jit} + \sum_{j=1}^{2} \beta_{11j} DPAY_{jit} \\
&\quad + e_{it}.
\end{aligned}
$$

where t = time in simulated weeks = 40, 41, . . . , 114 and i = transaction observations within each week = 1, 2, 3, . . . , n_t. There are potentially a different number of transactions each week. Complete variable definitions and expected signs are presented in table 1. One variable from each binary group was omitted and is referred to as the "base" in subsequent tables and figures.

Many traditional economic variables found in transaction price models are accounted for or held constant by the FCMS (Ward et al.). Reasons for including selected variables in transaction price models for fed cattle are well developed elsewhere. As a result, the discussion of model specification is brief.

Boxed beef price was included in the model because demand for fed cattle is derived from the demand for beef. The futures market price for the nearby live cattle contract was included because the futures market is an alternative

Table 1. Variable Definitions with Expected Signs

Variables	Variable Definition	Expected Sign
Dependent Variable		
$TPFC_{it}$	*i*th transaction price ($/cwt) for one pen of fed cattle in week *t*	N/A
Independent Variables		
BBP_{t-1}	Boxed beef price ($/cwt) for choice, yield grade 1–3 550–700 lb carcasses, lagged one week	Positive
$LCFMP_{t-1}$	Live cattle futures market closing price ($/cwt) for the nearby contract period, lagged one week	Positive
TM_{t-1}	Total number of pens (100 hd/pen) marketed, lagged one week	Negative
TSL_t	Total number of pens of cattle (100 hd/pen) on the market-ready show list, in week *t*.	Negative
PPL_t	Potential profit or loss ($/cwt) in week *t*, i.e., largest meatpacker's break-even price for 1,150 lb cattle less the feedlot break-even price for 1,150 lb cattle	Negative
$DFDLT_{jit}$	Binary dummy variables identifying feedlot firms, j = 1–8, 1 = *FDLT1* (Base), 2 = *FDLT2*, 3 = *FDLT3*, 4 = *FDLT4*, 5 = *FDLT5*, 6 = *FDLT6*, 7 = *FDLT7*, and 8 = *FDLT8*	Pos./Neg.
$DPKR_{jit}$	Binary dummy variables identifying meatpacking firms, j = 1–4, 1 = *PKR1* (Base), 2 = *PKR2*, 3 = *PKR3*, and 4 = *PKR4*	Pos./Neg.
DMA_{jit}	Binary dummy variables identifying marketing agreement period, j = 1–2, 1 = Agreement, 2 = Nonagreement (Base)	Pos./Neg.
$DNMP_{jit}$	Binary dummy variables identifying agreement participants and nonparticipants during the nonagreement periods, j = 1–2, 1 = Participants and 2 = Nonparticipants (Base)	Pos./Neg.
$DMAP_{jit}$	Binary dummy variables identifying participants and nonparticipants during the agreement periods, j = 1–2, 1 = Participants and 2 = Nonparticipants (Base)	Pos./Neg.
$DPAY_{jit}$	Binary dummy variables distinguishing monetary reward periods, j = 1–2, 1 = Reward, 2 = Nonreward (Base)	Pos./Neg.

arena of price discovery. Both boxed beef price (BBP_{t-1}) and futures market price ($LCFMP_{t-1}$) were lagged one week because decisions under uncertainty tend to be made based on market information reported most recently. Two variables were included to account for the supply of fed cattle. The first supply variable is the total number of pens marketed the previous week (TM_{t-1}). Previous research has found marketings to significantly affect prices paid for fed cattle (Schroeder et al. 1993). The second supply variable is unique to using FCMS data. Number of cattle on the show list (TSL_t) represents cattle that can be marketed in the current week at one of five weights, 1,100 to 1,200 pounds in 25-pound increments. Previous research has indicated that information on market-ready inventories is important in forecasting fed cattle prices (Bacon, Trapp, and Koontz).

Buyers and sellers negotiate transaction prices based on their respective break-even prices and perception of market conditions. The difference between the largest meatpacker's break-even price for the 1,150-pound cattle and the feedlot break-even price for the same weight cattle represents potential profits or losses (PPL_t) available to share in week *t*. Available profits or losses were used as a measure of the bargaining range or the distribution of profits or losses between buyers and sellers in previous work (Ward et al.). This variable measures relative bargaining advantage. If the estimated coefficient is 0.5, feedlots and packers split available profits equally. If the coefficient is less than 0.5, packers capture the larger share. Significant price differences are observed among simulated firms due to individual negotiation skills that are unique to each simulated feedlot and meatpacking firm.

Separate variables were included to account for price differences among the eight feedlot and four meatpacking firms ($DPKR_{jit}$).

The remaining variables address the main purpose of this study. The first variable indicated how much transaction prices differed during periods with and without exclusive marketing agreements (DMA_{jit}). The second marketing agreement variable measured price impacts for firms participating in the exclusive marketing agreements during agreement periods ($DMAP_{jit}$). A third agreement variable measured differences between prices experienced by participating and nonparticipating firms during periods when there were no agreements ($DNMP_{jit}$). The final variable measured the effects on transaction prices for fed cattle from rewarding market participants in the FCMS ($DPAY_{jit}$).

Transaction Price Variance Model

A transaction price variance model was estimated as part of the price-level model. Results from this variance model explain how exclusive marketing agreements affected the variation of transaction prices. The transaction price model was specified as a Weighted Random Effects Model (WREM) and estimated for unbalanced panel data using LIMDEP 6.0. The WREM model specification corrects for two forms of heteroskedasticity in the error term (e_{it}). The random effects part of this specification assumes the error term (e_{it}) contains two components:

$$(2) \quad e_{it} = v_{it} + u_t.$$

The first component is randomness of transaction prices within each week and the second component measures the random impact that is common to each week of trading. The model error term has the following properties:

$$(3) \quad E[u_t] = 0$$

$$(4) \quad \text{var}[u_t] = \sigma_u^2$$

$$(5) \quad \text{cov}[v_{it}, u_t] = 0$$

and

$$(6) \quad \text{var}[v_{it} + u_t] = \sigma_v^2 + \sigma_u^2 = \sigma^2.$$

Across weeks t and s, the disturbances are correlated:

$$(7) \quad \text{cor}[v_{it} + u_t, v_{is} + u_s] = \rho = \sigma_u^2/\sigma^2.$$

There are strong a priori reasons to suspect heteroskedasticity from random effects. There are distinct periods in the simulation where the bargaining power varies between feedlots being the stronger group to packers being the stronger group. Because of this, transaction prices are higher and then lower than can be explained by variables in the model. This specification is essentially capturing serial correlation in the model where the serial correlation is across trading weeks, not across individual transactions.

In addition to the heteroskedasticity captured in the random effects model, there was a second type of heteroskedasticity which was more significant. For each transaction within a given week, the observation associated with the market variables is identical. For example, the single boxed beef price for week 45 is used to explain all of the fed cattle transaction price observations for week 46. Errors associated with the transaction prices for a given week are not likely independent. If the market variables explain poorly (well) one transaction within a week, the same variables will likely explain poorly (well) other transaction prices for that week. The observations within a week are not independent. The observations in the transaction price model are weighted to correct for this dependence. This form of heteroskedasticity is modeled as

$$\begin{aligned}(8) \quad \sigma_{it}^2 = {} & \alpha_0 + \alpha_1 BBP_{t-1} + \alpha_2 LCFMP_{t-1} \\ & + \alpha_3 TM_{t-1} + \alpha_4 TSL_t + \alpha_5 PPL_t \\ & + \sum_{j=1}^{8} \alpha_{6j} DFDLT_{jit} + \sum_{j=1}^{4} \alpha_{7j} DPKR_{jit} \\ & + \sum_{j=1}^{2} \alpha_{8j} DMA_{jit} + \sum_{j=1}^{2} \alpha_{9j} DMAP_{jit} \\ & + \sum_{j=1}^{2} \alpha_{10j} DNMP_{jit} + \sum_{j=1}^{2} \alpha_{11j} DPAY_{jit} \\ & + \mu_{it}\end{aligned}$$

where variables were defined earlier. Observations in the random effects model (transaction price model) were weighted to correct for this form of heteroskedasticity (price variance model) using

$$(9) \quad w_{it} = 1/\sigma_{it}^2$$

Table 2. Descriptive Statistics for Selected Variables Across Subsample Periods

Period and Variable	Mean	Standard Deviation	Period and Variable	Mean	Standard Deviation
	Agreement Periods			Nonagreement Periods	
$TPFC$	81.11	1.99	$TPFC$	77.76	3.24
BBP_{t-1}	129.24	3.73	BBP_{t-1}	123.19	4.55
$LCFMP_{t-1}$	78.08	1.53	$LCFMP_{t-1}$	78.09	2.84
TM_{t-1}	36.50	5.14	TM_{t-1}	37.60	5.65
TSL_t	108.65	12.61	TSL_t	119.62	13.95
PPL_t	3.28	3.87	PPL_t	1.48	2.62
	Reward Periods			Nonreward Periods	
$TPFC$	79.07	3.49	$TPFC$	79.25	2.97
BBP_{t-1}	125.62	5.80	BBP_{t-1}	125.81	4.47
$LCFMP_{t-1}$	77.72	2.45	$LCFMP_{t-1}$	78.45	2.25
TM_{t-1}	27.35	5.86	TM_{t-1}	36.95	5.04
TSL_t	114.60	15.11	TSL_t	115.45	13.77
PPL_t	2.05	2.99	PPL_t	2.41	3.60

where σ_{it}^2 is the conditional variance [i.e., predicted values from equation (8)] for each observation.

The models were estimated iteratively to yield generalized least squares estimates. The random effects transaction price model was estimated first, equations (1) through (7). Residuals from this model were used to construct the variance model, equation (8). Predicted values from the variance model were then used as weights, equation (9), and the random effects transaction price model, equations (1) through (7), was re-estimated. Residuals from this price-level model were used to re-estimate the variance model and predicted values were then used as weights to re-estimate the random effects model. The procedure was iterated until the parameter estimates converged.

Variations of this model were estimated to evaluate the sensitivity of the conclusions about the impacts of the marketing agreement and reward periods (Dowty). We also assessed robustness of the results to different forms of heteroskedasticity.[4] Parameter estimates change slightly, but the conclusions drawn are not sensitive to minor respecifications of the transaction price and variance models.

[4] Tests for three common forms of heteroskedasticity were conducted (Judge et al.): (*i*) when the error variance is a linear function of the explanatory variables; (*ii*) when the error standard deviation is a linear function of the explanatory variables; and (*iii*) the multiplicative form. The variance form fit the data best and is specified in equation (8).

Empirical Results

The transaction price model explained 79.8% of the variation in fed cattle transaction prices. The random effects were found to be highly significant and reduced the significance of many independent variables. The price variance model explained 8.2% of the variation in the error variance model and tests for heteroskedasticity were highly significant. Weighting the observations reduced the significance of several of the independent variables that remain constant within each trading period.

Table 2 provides summary statistics for selected variables during experimental simulation periods. Table 3 provides parameter estimates and model statistics for the transaction price and price variance models.

Similar to previous studies, the price and quantity variables significantly affect fed cattle transaction prices (table 3). Boxed beef price (BBP_{t-1}), live cattle futures market price ($LCFMP_{t-1}$), number of cattle marketed (TM_{t-1}), and number of pens of cattle on the show list (TSL_t) all impact transaction prices in the anticipated direction.

The potential profit/loss each week (PPL_t) was also significant and negative as in previous work with FCMS data (Anderson et al., Ward et al.). However, the economic reasons for the negative, but robust, relationship are not clear. Differences in managerial and negotiation skills also existed among participants of the FCMS, leading to average trans-

Table 3. Parameter Estimates for the Transaction Period and Price Variance Models

Variable	Transaction Price Model	Price Variance Model
Intercept	26.243***	21.497***
	(3.907)	(6.136)
BBP_{t-1}	0.312***	−0.013
	(10.284)	(0.810)
$LCFMP_{t-1}$	0.279***	−0.203***
	(3.858)	(5.545)
TM_{t-1}	−0.057**	−0.088***
	(2.488)	(7.656)
TSL_t	−0.054***	0.018***
	(4.428)	(2.890)
PPL_t	−0.127***	−0.186***
	(2.822)	(8.114)
DFDLT1	Base	Base
DFDLT2	0.215***	−0.945***
	(2.679)	(2.980)
DFDLT3	0.659***	−1.593***
	(10.513)	(6.440)
DFDLT4	0.396***	−1.422***
	(6.176)	(5.789)
DFDLT5	*0.405****	*−0.891****
	(5.056)	*(2.815)*
DFDLT6	*0.454****	*−0.992****
	(6.980)	*(4.120)*
DFDLT7	*0.368****	*−0.915****
	(5.570)	*(3.744)*
DFDLT8	*0.052*	*−1.666****
	(0.082)	*(6.821)*
DPKR1	*Base*	*Base*
DPKR2	−0.409***	0.274
	(8.792)	(1.457)
DPKR3	−0.500***	0.114
	(11.370)	(0.621)
DPKR4	−0.080	0.515*
	(1.090)	(1.702)
DMA1	1.219***	0.389**
	(3.691)	(1.970)
DMA2	Base	Base
DMAP1	−0.698***	−0.821*
	(6.483)	(1.811)
DMPA2	Base	Base
DNMP1	−0.098	−0.547*
	(1.271)	(1.700)
DNMP2	Base	Base
DPAY1	0.030	0.456***
	(0.127)	(3.727)
DPAY2	Base	Base
R^2	0.798	0.082
Model significance	0.0001	0.0001
N	2,770	2,770

Note: Figures in parenthesis are *t*-statistics. Significance levels are denoted as follows: *** denotes 0.01, ** denotes 0.05, and * denotes 0.10.

action price differences among several feedlot ($DFDLT_{jit}$) and packing firms ($DPKR_{jit}$).

The price and quantity variables also had significant impacts on the variability of transaction prices. Higher live cattle futures prices and marketings led to decreased variability in transaction prices. Increases in the profit potential also led to lower variability. A higher potential profit likely results in less bargaining to discover an acceptable price. However, in-

creasing the size of the show list resulted in increased transaction price variability. Increasing the number of market-ready cattle appears to destabilize the negotiation process. There were significant differences in the variability across firms. Some firms may have attempted to more uniformly price their cattle than others.

Specific types of captive supplies have been found in previous research to have a negative relationship with fed cattle transaction prices (Schroeder et al. 1993; Ward, Koontz, and Schroeder). This study focused on a single captive supply type, a profit-sharing marketing agreement. Significant price differences existed between agreement and nonagreement periods. The coefficient for agreement periods (DMA_{jit}) in the transaction price model indicated that prices were \$1.22/cwt higher during the agreement periods than nonagreement periods. Additionally, transaction price variance was significantly greater (\$0.39/cwt) during agreement periods than during nonagreement periods. Imposition of the marketing agreement resulted in both expected and unexpected results. Higher prices were unexpected and are at odds with previous empirical work (Schroeder et al. 1993; Ward, Koontz, and Schroeder). Changes in the supply of available fed cattle and demand for those uncommitted cattle altered buyer-seller relationships. It was hypothesized that removal of a significant supply of fed cattle, via the commitment to packer #4, would result in lower prices for uncommitted cattle. However, nonparticipating packers competed intensely for the smaller supplies, resulting in higher prices for nonparticipating feedlots. More variability in prices during the agreement period was expected. Nonparticipating firms were forced to adjust to an abrupt, disruptive change in "normal" market conditions, introducing added uncertainty and leading to higher price variation.

Marketing agreement participants ($DMAP_{jit}$) realized significantly lower transaction prices (\$0.70/cwt) than did nonparticipants during agreement periods. In addition, the coefficient on the same variable in the price variance model indicated that participants realized significantly lower price variance (\$0.82/cwt.) compared with nonparticipants during the agreement periods. These results are likely related more to the profit-sharing nature of the imposed agreement than to marketing agreements generally, since most are not explicit profit-sharing arrangements. Participants were instructed to share information and negotiate a profit-sharing price. The profit-sharing price reduced price risk, but at a lower mean price. Packer #4 benefitted by paying lower prices for cash-market cattle and by having a consistently high percentage (about 75%) of its weekly volume committed to it in advance of having to purchase cattle in the cash market. Feedlots #2 and #5 benefitted by guaranteeing a market for their fed cattle when cattle reached the least-cost weight. Marketing agreement participants ($DNMP_{jit}$) did not realize significantly different transaction prices or price variation during nonagreement periods compared with nonparticipants.

Monetarily rewarding subjects of experimental economics research has been found to be an effective method of inducing subjects to maintain a high level of interest while participating in economic experiments. Previous experimental economics research results suggest that properly rewarding subjects controls their individual preferences in such a way that they remain competitive throughout the duration of the experiment. As a result, the extended competition allows the market to realistically respond to repeated applications of a particular economic treatment (Smith 1976, 1982; Plott; Friedman and Sunder). Results from the transaction price model indicate that fed cattle transaction prices were not significantly different between reward ($DPAY_{jit}$) and nonreward periods. However, the reward period coefficient ($DPAY_{jit}$) in the transaction price variance model indicated that transaction prices were significantly more variable (\$0.46/cwt) during periods when the subjects of experimental simulation were rewarded than during nonreward periods.

Conclusions

Marketing agreements have increased in importance in the fed cattle market during the past decade. However, access to industry data to measure their impacts is limited, despite increasing concerns about the effects such agreements have on price discovery. Experimental simulation offers an alternative methodology for studying certain kinds of price discovery questions. The Fed Cattle Market Simulator (FCMS) was developed to provide a realistic market framework and institutional structure in which market participants make repeated marketing/procurement decisions. Experimental simulation was used in this

study to estimate fed cattle transaction price impacts from a profit-sharing marketing agreement imposed on two feedlots and a packer in the FCMS. Data were collected from seventy-five trading weeks, totaling 2,770 transactions. Transaction price level and variability models were estimated to determine the effects from imposition of the profit-sharing marketing agreement.

Results for several economic variables were found to be generally consistent with previous research using industry data as well as previous FCMS studies. These variables included boxed beef prices, live cattle futures market prices, marketings, and dummy variables for individual feedlot firms and individual meatpacking firms. The potential profit/loss each week and show list size also affected transaction prices but such data are not readily and publicly available in the real-world fed cattle market.

The central focus of this study was on impacts of exclusive marketing agreements on the level and variability of fed cattle transaction prices. Transaction prices during the agreement periods were higher but more variable than during nonagreement periods. The reduction in available supplies for purchase and the large committed supplies to one packer introduced uncertainty into the market. Nonparticipating packers offset the reduced demand by the participating packer by paying higher prices for the reduced supply of fed cattle available to them. During the marketing agreement periods, agreement participants experienced lower but less variable transaction prices than did nonparticipants. However, this result may be related more to the profit-sharing nature of the imposed agreement than to agreements generally.

This research is the first to measure the change in market price from an abrupt change in market behavior regarding use of one type of captive supply. Care must be exercised in transferring results from this experimental simulation to the real-world fed cattle market. However, results suggest that abrupt changes in marketing arrangements can have a significant impact on price discovery, and, under some conditions, such an effect may be positive.

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