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Factors Affecting Preconditioned Calf Price Premiums: Does Potential Buyer Competition and Seller Reputation Matter?

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Feeder-calf prices are determined by the interaction of many factors. This study uses transaction data from Iowa preconditioned and regular feeder-calf auction sales to quantify the impact of a wide variety of factors, several of which have not been used in previous studies on feeder-calf prices. Notably, market premiums for preconditioned sales versus regular sales, feedlot capacity utilization, and seller reputation are found to be significant factors affecting feeder-calf prices. Estimated coefficients are then used to predict prices to demonstrate how this information can be used in making management and marketing decisions.

Key words: feeder calves, feedlot capacity, hedonic model, preconditioning, price analysis, price differentials, seller reputation

Introduction

Preconditioning programs, which involve performing a series of health protocols and other management practices to improve the health status and post-weaning performance of calves, have continued to capture the interest of producers. These programs provide opportunities for cow-calf producers to more fully capture their investment in health programs, nutritional practices, and overall management systems before calves enter a stocker, backgrounding program, or a feedlot. Preconditioning value is realized through reduced incidences and associated costs of morbidity, improved performance in terms of weight gain and feed efficiency, reductions in drug use and labor required to treat and manage sick cattle, and improved beef product quality (Lalman and Mourer, 2014). These factors suggest that preconditioning efforts create value for the entire supply chain (Nyamusika et al., 1994; Busby et al., 2004; Dhuyvetter, Bryant, and Blasi, 2005; Lalman and Mourer, 2014).

Recent efforts in the U.S. beef industry will likely increase the interest in preconditioning programs. Efforts that serve to increase information flow and management coordination up and down the supply chain, such as value-based marketing, beef alliances, beef brands, source verification, individual animal identification, and quality and process assurance programs are generally compatible with management practices such as preconditioning. In this regard, stronger signals and incentives are created to encourage the adaptation of the best management practices, such as those associated with preconditioning (Lalman and Mourer, 2014).

The numerous market and sale conditions that cow-calf producers and buyers of feeder calves face motivate this study to determine how evolving changes are impacting or being valued in the market over time. The primary objective of this study is to determine the implicit values of feeder-

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calf attributes and to quantify the effects of both market and sale dynamics. Specific objectives include (a) determining the impact various characteristics have on feeder-calf prices, (b) determining whether a price difference between calves marketed at a preconditioned sale and a regular sale exists and how it varies over time, (c) determining the impact that sale-specific characteristics have on feeder-calf prices given the decision to market calves at a preconditioned sale, and (d) determining whether a seller reputation exists for calves sold at a preconditioned sale.

Background and Previous Literature

Previous studies have examined determinants of feeder-calf transaction prices and generally found that sale-lot calf characteristics (e.g., weight, lot size, sex, frame, muscling), market characteristics (e.g., futures prices, transportation costs), and seasonality explain much of the variability in transaction prices within a particular market (Faminow and Gum, 1986; Schroeder et al., 1988; Lambert et al., 1989; Coatney, Menkhaus, and Schmitz, 1996; Sartwelle et al., 1996a,b; Dhuyvetter and Schroeder, 2000; Smith et al., 2000; Ward, Ratcliff, and Lalman, 2005; Barham and Troxel, 2007). Research has followed producer implementation of myriad value-added health and other management programs (Ward and Lalman, 2003; Avent, Ward, and Lalman, 2004; King and Seeger, 2005; Dhuyvetter, Bryant, and Blasi, 2005; Blank et al., 2006; King et al., 2006; Bulut and Lawrence, 2007; Blank, Forero, and Nader, 2009; Williams et al., 2012; Zimmerman et al., 2012; Lalman and Mourer, 2014; Williams et al., 2014). Given the increased focus on adding value and having quality and process assurance-based programs, preconditioning programs will likely continue to be important in the beef industry. Furthermore, with cattle and beef prices at record levels, improved health and performance of calves is critically important for both buyers and sellers of feeder calves. Thus, it is important to understand the value of marketing preconditioned calves, especially under evolving market and sale conditions.

This study devotes attention to several fundamental components of feeder-calf price discovery. Nearly every previous study on feeder-calf price determinants discusses price differentials for different calf characteristics (including certifications or marketing channels) and market forces. However, the literature is sparse on research into seller reputation and potential buyer competition. If seller reputation and potential buyer competition effects exist, then the inclusion of these important variables in this analysis should provide more consistent parameter estimates than those reported in previous studies.

Feeder-calf auctions are a prime example of an agricultural market containing quality-differentiated products—a heterogeneous set of producers selling calves to a heterogeneous set of buyers likely represents a wide range in quality. Calf buyers use visual inspections of calves' physical characteristics, market characteristics, knowledge of a location's reputation, and knowledge of a seller's reputation to make bidding decisions. Building reputation and integrity for both a preconditioned sale and individual sellers of preconditioned calves takes time and effort. Several studies have found reputation to be an important driver of prices for purebred bulls (Chvosta, Rucker, and Watts, 2001; Dhuyvetter et al., 1996; Jones et al., 2008), but the impact of seller reputation for feeder calves has generally not been examined. One exception is Turner, McKissick, and Dykes (1993), who found that seller reputation can be an important factor in buyers' price-bidding decisions in some electronic feeder cattle markets in Georgia.

Bulut and Lawrence (2007) indicate that the reputation of sellers is of less concern in a feeder cattle auction environment, given that the majority of producers only market once or twice a year and only sell a small number of cattle. They examine the potential benefit of third-party certification (TPC) for a preconditioning claim and find a significant premium associated with TPC. Chymis et al. (2007) discuss how asymmetric information in cattle auctions can lead to revaccination problems; however, seller reputation might preclude the need for TPC and reduce the problems associated with asymmetric information as markets develop.

The cattle-feeding sector has undergone long periods with relatively poor returns. Persistently negative returns are likely a sign of overcapacity in a feedlot industry that is slow to adjust. According to the Kansas State University Focus on Feedlots survey, the monthly average net returns for finishing steers in Kansas feedlots from January 2002 to November 2014 was -$20.62 per head (Tonsor, 2015). As the size of the U.S. cowherd has declined with minimal change in total feedlot capacity, cattle feeders have likely faced increased competition to keep cattle in their feedlots. Despite claims about the importance of excess capacity in the feedlot sector on feeder-calf prices, the price impact of feedlot capacity utilization has not been well established. This is the first study to create a model of feeder-calf price determinants that incorporates feedlot capacity utilization, which can account for variation in competition and the leverage position of the feedlot versus cow-calf producer.

Hedonic Pricing Model

The price received for a lot of feeder calves is modeled as a function of the physical characteristics (*C*) of the sale lot and the fundamental market forces (*M*) of supply and demand for feeder calves at the observed time. This type of modeling, known as the hedonic pricing model, is commonly used in the literature to study the valuation of feeder calves. We adopt a similar specification to Bulut and Lawrence (2007) and Zimmerman et al. (2012). The hedonic pricing model can be generally written as

$$Price_{it} = \sum_{k} V_{ikt} C_{ikt} + \sum_{h} R_{ht} M_{ht}, \quad (1)$$

where i is an individual lot of calves, k is a specific physical characteristic, h is a specific market force, and t is the auction date. The value of a specific physical characteristic in a sale lot is represented by V, and the effect of specific market force on price is represented by R. Equation (1) indicates that the price per hundredweight for each lot of calves is equal to the sum of the marginal values of production for each lot characteristic and the sum of market forces at a particular auction (Zimmerman et al., 2012). Thus, the hedonic framework provides the ability to isolate the effects of individual characteristics on transaction prices and gives us insight into the value placed on specific feeder-calf attributes as well as market and sale dynamics.

Data

The Iowa feeder cattle auction market is an ideal market to study for our model. The Northwest Iowa Preconditioned Sale Committee, Iowa Cattlemen's Association, and Iowa Veterinary Medical Association (IVMA) co-sponsor preconditioned sales in December, January, and February. These sales offer green-tag and gold-tag preconditioning programs, which are administered by a joint effort of the IVMA and the Iowa Cattlemen's Association.

To meet the green-tag standard, a calf must have been weaned for thirty days, bunk adjusted, vaccinated for major infectious diseases (IBR, PI-3, BVD, BRSV, 7-way Clostridial, *Mannheimia haemolytica*, and *Histophilus somni*), treated for internal and external parasites, and castrated and dehorned, if necessary. Green tags are issued to veterinarians by IVMA, and each tag carries an identification number. The traditional green-tag program also includes an IVMA Pre-Conditioning Certificate that must be signed by the attending veterinarian and the seller and ensures that all calves listed in the certificate by the green-tag number have been weaned at least thirty days and owned at least sixty days by the seller.

The gold-tag program requires the mandatory green-tag procedures of vaccinations, bunk adjusted, treatment for internal and external parasites, castration, dehorning, and sixty-day ownership. However, gold-tag calves receive a second set of vaccinations (a second *Mannheimia haemolytica* vaccination is optional) and have been weaned for a minimum of forty-five days. The

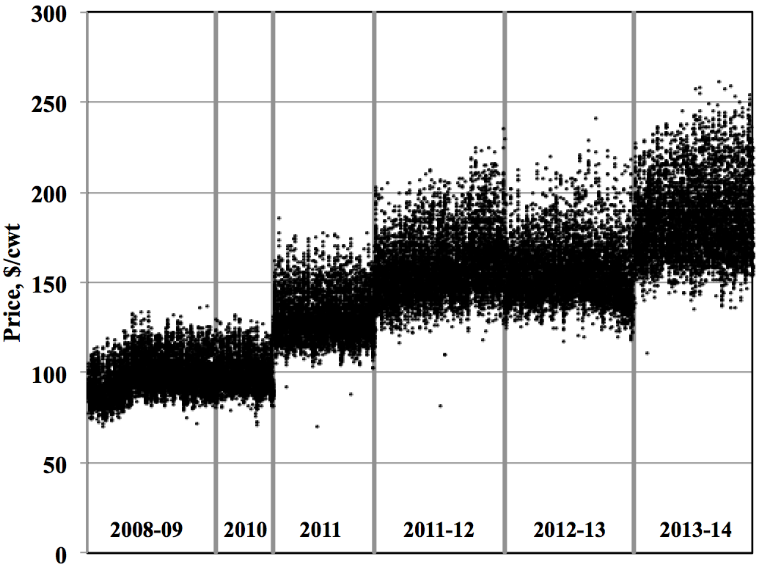

Figure 1. Iowa Feeder Calf Transaction Prices by Market Year

gold tag and "gold certificate" certify that re-vaccination was performed at least fourteen days before the sale date.[1]

From December 2008 to February 2014, data were collected on individual lots of calves sold through one preconditioned sale and eleven regular auction sales occurring the week of and the week following the preconditioned sale.[2] Livestock auctions surveyed were located in Bloomfield, Centerville, Creston, Denison, Dunlap, Humeston, Knoxville, Lamoni, Russell, Sheldon, Sigourney, and Tama, representing auction markets available to producers across the state of Iowa.[3]

Transaction-level data from both the preconditioned sales and regular sales were obtained from U.S. Department of Agriculture market reporters. Modeling individual transaction prices enables an estimation of factors affecting individual sales transactions that could not be accounted for using aggregate data. For example, modeling procedures were able to better account for lot characteristics that might change as market conditions change. All transactions are illustrated in figure 1, with each point representing a transaction price. The average price was $141.71/cwt (hundredweight); however, considerable variation is present over time and across transactions. Preconditioned sales typically occurred in December, January, and February. However, in the case of December 2009 and December 2010, a U.S. Department of Agriculture market reporter was not present at the sale to report frame size and muscle scores. In addition, a preconditioned sale did not occur in February 2010 due to limited potential sale volume.

Data collected include price, number of head in transaction (lot size), calf gender (steer or heifer), frame size, and muscle scores. Frame size and muscle scores were determined based on the U.S. Standards for Grades of Feeder Cattle (U.S. Department of Agriculture, Agricultural Marketing Service, 2000). A trained Iowa State University Beef Program Specialist worked with the U.S. Department of Agriculture market reporter present at the sales to collect additional data for the preconditioned calf sales. These data included the certified preconditioning program (green tag or gold tag), hair coat color (black, black and white, silver, shades of yellow and/or white, red, red and

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[1] More information about the preconditioning programs can be found at http://www.iowavma.org/.

[2] Transactions were collected from regular sales in the same week and the week following the preconditioned sale to capture alternative market opportunities with similar market conditions.

[3] Feeder calves sold at regular sales may or may not have been preconditioned; however, data provided by U.S. Department of Agriculture's Agricultural Marketing Service did not include any preconditioning program information.

white, and other), health status (unhealthy or healthy), sale order, and seller name. Supplementary data collected for this study included Chicago Mercantile Exchange feeder cattle futures prices, U.S. Energy Information Administration diesel fuel prices, and Iowa feedlot capacity information.

Feedlot capacity utilization for feedlots with 1–999 head capacity and 1,000+ head capacity was estimated with U.S. Department of Agriculture National Agricultural Statistics Service monthly cattle-on-feed estimates. Iowa is the only state in the United States that reports monthly cattle-on-feed estimates for both 1–999 head capacity and 1,000+ head capacity feedlots. Feedlot capacity utilization was defined as the number of cattle on feed in a given month divided by feedlot capacity in number of head for both "small" and "large" feedlots (i.e., 1–999 head and 1000+ head).[4] In addition, since the monthly cattle-on-feed estimates are as of the first of each month, a linear relationship between two successive months was used to estimate the number of cattle for a specific day within a particular month. For consistency, a similar process was used to convert diesel prices from weekly to daily.

Empirical Models

The hedonic pricing models estimated in this study were based on previous research and the novel transaction characteristics from the data described. Two hedonic models are estimated. The first model estimates the coefficients related to preconditioned sales versus regular auction market feeder-calf sales. The second model estimates the coefficients related to marketing calves at a preconditioned sale. Table 1 provides definitions and tables 2 and 3 provide summary statistics of variables included in the models.

Preconditioned Sale versus Regular Sale Model

In order to estimate the expected premiums, historical transaction prices of feeder calves sold through preconditioned sales and regular sales were used. The empirical model can be generalized as

$$\begin{aligned} Price_{it} = \; & f(Quantity_{it}, Weight_{it}, Lotsize_{it}, Gender_{it}, \\ & Frame_{it}, Muscle_{it}, FeederFutures_t, Diesel_t, \\ & LargeUtilization_t, SmallUtilization_t, Month_t, Location_i), \end{aligned} \tag{2}$$

where i refers to an individual transaction at time t.

The dependent variable *Price* is the average price per hundredweight (cwt) for each individual transaction (lot). *Quantity* is the total number of head sold at each sale for the data used in the analysis. The quantity for any given sale is assumed fixed and exogenously given, but it will vary across location and time.[5] Larger sale quantities can be more aggressively advertised by sale barns through descriptions of cattle to be marketed and placement of advertisements in various media channels ahead of sale time. More advertising may attract more buyers, which in turn could increase competition among buyers, positively affecting price. On the other hand, because supply is larger, price may be negatively affected (Bulut and Lawrence, 2007).

Characteristics unique to each lot of calves—such as lot size, gender, and average weight—are expected to affect the transaction price. Therefore, our model includes individual lot characteristics

[4] Capacity of Iowa feedlot operations for size categories 1–999 head capacity and 1,000+ head capacity was provided by U.S. Department of Agriculture National Agricultural Statistics Service.

[5] A reviewer correctly points out that in rare circumstances sellers may react during the sale to favorable or unfavorable price conditions by changing the number of head sold. Auction barn owners involved in this study indicated that they were aware of the number of cattle that would be brought to sale before the day of the sale. Furthermore, the assumption of supply being fixed is consistent with the majority of similar previous studies (Faminow and Gum, 1986; Bulut and Lawrence, 2007; Zimmerman et al., 2012).

Table 1. Definitions of Variables

Dependent Variable	Description
Price	Location-specific feeder-calf transaction price ($/cwt)

Independent Variables	Description
Sale Characteristics	
Time of sale	Consists of four binary (0,1) variables assigned 1 if sold, (i) quarter 1, (ii) quarter 2, (iii) quarter 3, or (iv) quarter 4, and each variable was assigned 0 otherwise.
Calf Characteristics	
Weight	Average per-head weight of animals in a lot (pounds).
Lot size	Number of head in a lot (head).
Gender	Gender of animals, gender = 0 if steers and = 1 if heifers.
Frame size	Frame size, frame size = 0 if Medium and = 1 if Medium and Large.
Muscle score	Muscle score, muscle score = 0 if muscle score 1and = 1 if muscle score 1–2.
Color	Consists of seven binary (0,1) variables assigned 1 if hair coat color, (i) black, (ii) black and white, (iii) silver, (iv) shades of yellow and/or white, (v) red, (vi) red and white, or (vii) other, and each variable was assigned 0 otherwise.
Health status	Assessment of health status, health = 0 if healthy and = 1 if unhealthy.
Preconditioned tag	Preconditioning program, preconditioning = 0 if green-tag and = 1 if gold-tag.
Market Characteristics	
Feeder cattle futures price	Feeder cattle futures settlement price of nearby feeder cattle contract for the trading day of the sale date ($/cwt).
Diesel price	Daily retail price of taxable diesel fuel (cents/gallon).
Small feedlot capacity utilization	Daily capacity utilization of Iowa feedlots 1–999 head capacity (percent).
Large feedlot capacity utilization	Daily capacity utilization of Iowa feedlots 1000+ head capacity (percent).
Seasonal Characteristics	
Month	Consists of three binary (0,1) variables assigned 1 if month, (i) December, (ii) January, or (iii) February, and each variable was assigned 0 otherwise.
Market year	Consists of six binary (0,1) variables assigned 1 if market year, (i) 2008–09, (ii) 2010, (iii) 2011, (iv) 2011–12, (v) 2012–13, (vi) 2013-14, and each variable was assigned 0 otherwise.
Location Characteristics	
Location	Consists of twelve binary (0,1) variables assigned 1 if sale location, (i) 1, . . . , or (xii) 12, and each variable was assigned 0 otherwise.
Seller Characteristics	
Seller	Consists of 190 binary (0,1) variables assigned 1 if seller, (i) 1, . . . , or (cxc) 190, and each variable was assigned 0 otherwise.

as explanatory variables to account for specific attributes of calves in a transaction. The number of head marketed in a transaction (*Lotsize*) is included. Buyers might find efficiency gains in filling orders and shipping with larger lot sizes, suggesting a positive relationship between price and lot size. The average weight of cattle marketed in a transaction (*Weight*) is included because cattle buyers prefer cattle within a specific weight range. A negative relationship exists between price and weight. Both linear and quadratic terms for *Lotsize* and *Weight* are included because these variables are expected to be nonlinearly related to price (Bulut and Lawrence, 2007). A binary variable, *Gender*, accounts for quality differences among calves associated with gender (steers versus heifers). Binary variables for *Frame* size and *Muscle* score are also included.

Table 2. Summary Statistics of Preconditioned Sale and Regular Sale Transactions

Variable	Mean	Standard Deviation
Price	141.711	34.491
Sale Characteristics		
Quantity	1958.230	851.968
Calf Characteristics		
Weight	592.644	121.670
Lot size	12.804	13.443
Heifer	0.464	0.499
Steer	0.536	0.499
Medium	0.007	0.082
Medium and Large	0.993	0.082
Muscle 1	0.840	0.366
Muscle 1–2	0.160	0.366
Market Characteristics		
Feeder cattle futures price	133.517	27.765
Diesel price	343.825	62.407
Large feedlot capacity utilization	65.984	7.647
Small feedlot capacity utilization	54.373	2.134
Seasonal Characteristics		
January	0.579	0.494
February	0.222	0.416
December	0.199	0.399
Market year (2008–09)	0.193	0.395
Market year (2010)	0.086	0.280
Market year (2011)	0.152	0.359
Market year (2011–12)	0.196	0.397
Market year (2012–13)	0.193	0.395
Market year (2013–14)	0.180	0.384
Location Characteristics		
Preconditioned Sale	0.064	0.244
Regular sale 1	0.034	0.181
Regular sale 2	0.023	0.151
Regular sale 3	0.095	0.294
Regular sale 4	0.178	0.383
Regular sale 5	0.146	0.353
Regular sale 6	0.052	0.222
Regular sale 7	0.069	0.253
Regular sale 8	0.076	0.265
Regular sale 9	0.117	0.321
Regular sale 10	0.048	0.215
Regular sale 11	0.098	0.297
N	34,414	

Table 3. Summary Statistics of Preconditioned Sale Transactions

Variable	Mean	Standard Deviation
Price	150.023	34.139
Sale Characteristics		
Quantity	1236.580	527.894
Qtr1	0.248	0.432
Qtr2	0.244	0.429
Qtr3	0.249	0.433
Qtr4	0.258	0.438
Calf Characteristics		
Weight	570.503	126.125
Lot size	6.963	6.447
Heifer	0.462	0.499
Steer	0.538	0.499
Medium	0.069	0.253
Medium and Large	0.931	0.253
Muscle 1	0.627	0.484
Muscle 1–2	0.373	0.484
Black	0.784	0.412
Black and white	0.032	0.176
Silver	0.024	0.154
Yellow and/or white	0.014	0.118
Red and White	0.112	0.315
Red	0.011	0.106
Other	0.022	0.148
Unhealthy	0.010	0.100
Green-tag	0.761	0.427
Gold-tag	0.239	0.427
Market Characteristics		
Feeder cattle futures price	138.213	26.713
Diesel price	354.086	57.355
Large feedlot capacity utilization	67.142	6.767
Small feedlot capacity utilization	54.252	2.240
Seasonal Characteristics		
January	0.573	0.495
February	0.205	0.404
December	0.221	0.415
Seller Characteristics		
Seller	N/A	N/A
N	2,186	

Additional price determinants are included in the model. Feeder cattle futures prices (*FeederFutures*) account for current market conditions, diesel fuel prices (*Diesel*) account for changing transportation costs over time, and measures of feedlot capacity utilization (*SmallUtilization* and *LargeUtilization*) account for variation in local competition or changes in cattle feeding versus cow-calf producer market leverage over time. Squared values of the feedlot capacity utilization variables are also included to allow for a potential nonlinear effect.

Seasonality (*Month*) is expected to have varied effects on price depending on seasonal supply and demand conditions. Seasonal interactions between weight and weight squared are included to detect seasonal preferences for different weights of calves (Schroeder et al., 1988).

Due to confidentiality restrictions, specific locations are not identified. Thus, locations are identified as *PreconditionedSale* and *RegularSale1* through *RegularSale11*. The empirical model specifies two different effects of location on price. The term *Location* is the direct effect of the location on price. Each location is associated with calves marketed and buyers present, compared to that of a benchmark location. The location of each auction market is included as a binary variable in the model, and the resulting coefficient may be positive or negative depending on how that location compares to the benchmark location. Prices vary by location for a number of reasons (e.g., reputation of the sale barn, type/number of cattle in the region, number of buyers in the region, local feed prices). Apart from the direct effect of location, interaction terms cover a second effect of location; the impact of location on price is likely a function of lot characteristics and market factors. To allow for this, the binary variable for the preconditioned sale location was interacted with *Quantity*, *Weight*, *Lotsize*, *Gender*, and *Month*. Interactions with *MarketYear* were also included to allow for year-over-year patterns in buying activity between the regular sales and the preconditioned sale.

Selecting a reference transaction was necessary to obtain a regressor matrix of full rank so that the relative discounts and premiums in the model could be calculated. An arbitrarily chosen transaction of steers, medium framed, muscle score 1, sold at the preconditioned sale in December during the first market year (2008–09) was used as a reference lot. The results are invariant to the reference choice.

Preconditioned Sale Model

Given the decision to market calves at the preconditioned sale location, the following empirical model can be generalized as

$$\begin{aligned} Price_{it} = {} & f(Quantity_{it}, SaleQtr_{it}, Weight_{it}, Lotsize_{it}, Gender_{it}, \\ & Frame_{it}, Muscle_{it}, Color_{it}, HealthStatus_{it}, PCTag_{it}, FeederFutures_{t}, \\ & Diesel_{t}, LargeUtilization_{t}, SmallUtilization_{t}, Month_{t}, Seller_{t}), \end{aligned} \tag{3}$$

where i refers to an individual transaction at time t.

Given the additional information available for the preconditioned sales, there are several variables unique to this equation. Buyer activity has been shown to exhibit a within-sale pattern, suggesting a corresponding within-sale price pattern (Schroeder et al. 1988). Binary variables for each quarter of the sale (*SaleQtr*) were included to allow for quarter-of-sale patterns in buying activity. Binary variables for hair coat color (*Color*) were included as a proxy for breed or genetics.[6] Black hair coat typically signals Angus breed genetics, and whether black calves bring significant price premiums over non-black calves is investigated here. Unhealthy calves increase potential treatment costs and mortality rates, hence reducing feedlot efficiency. Calves were categorized as unhealthy if they were sick, nonconforming (e.g., rat-tail, lame, bad foot, bad eye, etc.), or both.[7] A

[6] At auction, buyers rarely know breed, but they do observe hair coat color based on visual inspection.

[7] Calves were categorized based on health status by the same trained Iowa State University Extension Beef Specialist over the entire data collection period providing consistency across this variable. The same classification system was used in Bulut and Lawrence (2007).

binary variable was included for *PCTag* to account for the difference in the green-tag and gold-tag programs.

Due to confidentiality restrictions, specific seller names are not identified. Thus, individual sellers are identified as *Seller*1 through *Seller*190. Seller variables are included as a proxy for reputation to investigate whether certain sellers receive significant price premiums or discounts after accounting for the characteristics of their cattle and sale and market conditions. The simplest and most inclusive criterion for investigating reputation effects on feeder-calf prices was to represent each seller who sold a lot with a binary variable. Over the fifteen preconditioned sales there were an average of twenty-nine sellers at a sale (min = 12, max = 51, std dev = 12.9) with an average of five (min = 1, max = 16, std dev = 2.1) transactions per seller. For the 190 sellers, the average number of transactions over the fifteen preconditioned sales was twelve (min = 1, max = 42, std dev = 10.1). Even though a seller may only sell a small number of calves once or twice a year, their reputation may be important if this is a distinguishing factor of heterogeneous calves presented at sale.

An arbitrarily chosen transaction of green-tag, healthy, black hair coat, steers, medium framed, muscle score 1, sold by seller 1 in the first quarter of the sale in December was used as the reference lot.

Results

The use of a fixed-effects estimator allows for the control of time-invariant unobservable factors that may impact the transaction price.[8] Binary variables are defined for each location in equation (2) and for each seller in equation (3). The regression is a least-squares dummy variable model, a fixed-effects model with constant slopes but intercepts that differ according to the cross-sectional unit, in this case location (equation 2) or seller (equation 3).

Following Greene (2003), an F-test resembling the structure of the F-test for R^2 change was used to test the hypothesis that location and seller constants are all equal, thereby testing the significance of the fixed effects. Rejecting the null hypothesis in both cases suggests that a pooled model omits important time-invariant location and seller effects, and hence the fixed-effects model is appropriate in both cases.

The Durbin-Watson test (Durbin and Watson, 1971) was used to detect the presence of serial correlation. Residuals in each model were tested for heteroskedasticity using White's test (White, 1980). The results show the coexistence of serial correlation and heteroskedasticity. Standard errors are obtained by exploiting the Newey and West covariance estimator (Newey and West, 1987).

The hedonic models were specified linearly.[9] Cropper, Deck, and McConnell (1988) find that the linear-specification hedonic model performs as well as alternative functional forms when attributes are omitted or proxies used.

Empirical results from the hedonic pricing models are presented in tables 4 and 5. The coefficient estimates refer to changes in feeder-calf prices in dollars per hundredweight from one-unit changes in the independent variables. A positive coefficient represents a premium for the particular characteristic while a negative coefficient indicates a discount.

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[8] The Durbin-Wu-Hausman test was used to determine whether the time-invariant unobservable factors should be treated as a fixed effect or random effect (Wu, 1973). The test was performed by obtaining the group means of the time invariant variables and adding them to the estimated random effects model. Then the joint hypothesis that the coefficients on the group means are all zero was tested. The hypothesis that the individual effects are uncorrelated with the other regressors was rejected, suggesting that these effects are correlated with other variables in the model. Thus, the fixed effects model is appropriate.

[9] We also considered a log-linear model. Box-Cox regressions suggest that a log-linear functional form is more appropriate. However, the difference in "fit" is slight. In this case, the linear functional form is preferred because the price-per-hundredweight interpretation is more straightforward and tractable for model predictions. General conclusions from each model specification are qualitatively the same.

Table 4. Coefficient Estimates of Preconditioned Sale and Regular Sale Transactions Model

Variable	Coefficient Estimate	Standard Error	Variable	Coefficient Estimate	Standard Error
Intercept	−220.199***	20.994	Location Characteristics		
			Regular sale 1	−6.955***	2.633
Sale Characteristics			Regular sale 2	−7.048***	2.635
Quantity	0.0011***	0.0001	Regular sale 3	−7.343***	2.628
			Regular sale 4	−4.182	2.627
Calf Characteristics			Regular sale 5	−4.936*	2.629
Weight	−0.205***	0.006	Regular sale 6	−8.099***	2.631
Weight-squared	0.0001***	0.000005	Regular sale 7	−7.677***	2.628
Lot size	0.236***	0.018	Regular sale 8	−7.907***	2.629
Lot size-squared	−0.0004***	0.0001	Regular sale 9	−7.732***	2.630
Lot size × Weight	−0.0002***	0.00003	Regular sale 10	−8.457***	2.629
Heifer	−47.490***	1.391	Regular sale 11	−8.685***	2.628
Heifer × Weight	0.075***	0.005			
Heifer × Weight-squared	−0.00003***	0.000004	Interactions		
Medium and Large	5.086***	0.451	PC sale × Quantity	−0.002**	0.001
Muscle 1–2	−7.022***	0.101	PC sale × Weight	−0.015	0.009
			PC sale × Weight-squared	0.00001	0.00001
Market Characteristics			PC sale × Lot size	0.711***	0.136
Feeder cattle futures	1.097***	0.005	PC sale × Lot size-squared	−0.012***	0.002
Diesel price	−0.020***	0.004	PC sale × Lot size × Weight	−0.0004*	0.0002
Large capacity utilization	−4.530***	0.145	PC sale × Heifer	4.323***	0.293
Large capacity utilization-squared	0.038***	0.001	PC sale × January	−0.462	0.865
Small capacity utilization	15.738***	0.739	PC sale × February	−6.180***	0.483
Small capacity utilization-squared	−0.138***	0.007	PC sale × Market year $_{(2010)}$	1.292*	0.783
			PC sale × Market year $_{(2011)}$	2.310***	0.666
Seasonal Characteristics			PC sale × Market year $_{(2011--12)}$	4.195***	0.579
January	10.880***	1.768	PC sale × Market year $_{(2012--13)}$	1.512**	0.687
January × Weight	−0.022***	0.006	PC sale × Market year $_{(2013--14)}$	5.731***	0.799
January × Weight-squared	0.00001	0.00001			
February	22.398***	2.117	R^2	0.965	
February × Weight	−0.047***	0.007	RMSE	6.477	
February × Weight-squared	0.00001**	0.00001	N	34,414	

Notes: Single, double, and triple asterisks (*, **, ***) indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Table 5. Coefficient Estimates of Preconditioned Sale Transactions Model

Variable	Coefficient Estimate	Standard Error
Intercept	−750.261***	117.100
Sale Characteristics		
Quantity	−0.002	0.001
SaleQtr2	−0.571	0.556
SaleQtr3	−0.402	0.567
SaleQtr4	−0.026	0.631
Calf Characteristics		
Weight	0.001	0.025
Weight-squared	−0.0001***	0.00002
Lot size	0.772***	0.163
Lot size-squared	−0.010***	0.002
Lot size × Weight	−0.0004	0.0003
Heifer	−0.234	5.413
Heifer × Weight	−0.051***	0.019
Heifer × Weight-squared	0.0001***	0.00002
Medium and Large	5.095***	0.697
Muscle 1–2	−3.852***	0.381
Black and white	−1.132	0.922
Silver	−1.290	1.081
Yellow and/or white	−2.675***	0.954
Red and White	−4.487***	1.658
Red	−0.933	0.571
Other	−2.634	2.399
Unhealthy	−11.937***	1.934
Gold-tag	−2.146**	0.847
Market Characteristics		
Feeder cattle futures	1.170***	0.035
Diesel price	−0.024	0.023
Large capacity utilization	−3.085***	1.030
Large capacity utilization-squared	0.026***	0.008
Small capacity utilization	30.598***	4.287
Small capacity utilization-squared	−0.270***	0.039
Seasonal Characteristics		
January	60.890***	7.206
January × Weight	−0.208***	0.026
January × Weight-squared	0.0002***	0.00002
February	67.310***	8.615
February × Weight	−0.262***	0.031
February × Weight-squared	0.0002***	0.00003
Seller Characteristics		
Seller	(Figure 7)	
R^2	0.959	
RMSE	6.915	
N	2,186	

Notes: Single, double, and triple asterisks (*, **, ***) indicate statistical significance at the 10%, 5%, and 1% level, respectively.

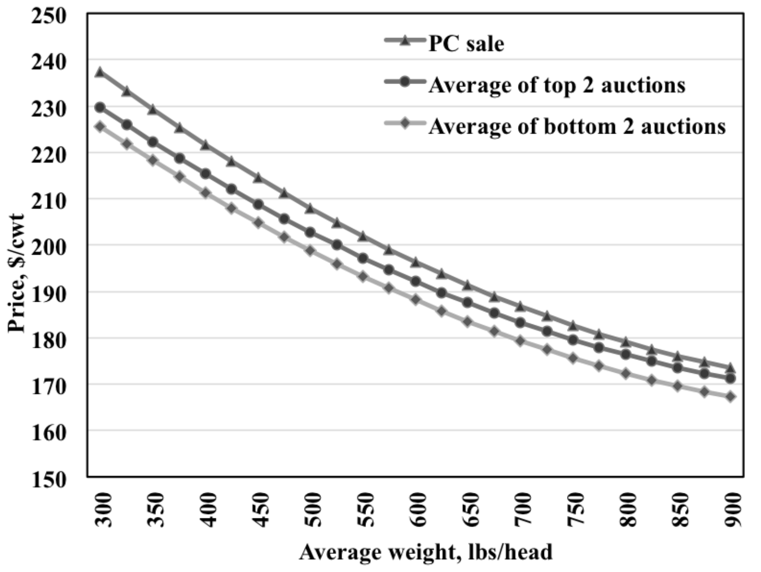

Figure 2. Estimated Price versus Selling Weight, Steers, 2013–2014

Preconditioned Sale versus Regular Sale

As expected, given the large sample size, almost all estimated coefficients are statistically significant (table 4). However, direct interpretation of a number of the coefficients is somewhat difficult because of the many sale location interaction variables in equation (2).

Medium- and large-framed calves brought a significant premium ($5.09/cwt) relative to medium-framed calves. Lots with a muscle score of 1–2 brought a significant discount ($7.02/cwt) relative to lots with a muscle score of 1.

As expected, cash prices are positively related to feeder cattle futures. For every $1/cwt increase in futures price, cash prices increase $1.10/cwt. The impact of diesel price was negative, with a $0.10/gallon increase associated with a decrease in calf price of $0.20/cwt. Presumably, the negative relationship is because higher transportation costs make calves less attractive.

High-volume sales received higher prices, but the value was relatively low ($1.10/cwt for every 1,000-head increase). This likely reflects higher volume sales attracting more buyers, and thus the increased quantity is associated with stronger demand. The impact of lot size is for increasing prices at a decreasing rate—the optimal lot size for calves sold in regular auctions is 130 head, but the optimal size of a preconditioned (PC) sale was only 24 head (average and range for PC sale was considerably lower than regular auctions).

To illustrate the impact of factors with interactions that are more complex, results are shown in figures with predicted prices. Figure 2 shows the predicted price for steers versus selling weight at the PC sale and the average of the top and bottom two auction sales (all other variables at their mean values for the 2013–14 market year). Consistent with previous research, prices decline at a nonlinear rate as weight increases. The advantage of the preconditioned calves also declines at heavier weights, as would be expected. Heifer prices follow a similar declining rate pattern, but the premium on PC calves is higher (data not shown).

Figure 3 displays the six-year average predicted price premium for calves sold in the PC sale versus the eleven regular sales.[10] The premiums are quite consistent across location with

[10] Prices were calculated for each location for each year based on means of other variables (e.g., futures price, diesel, weight, feedlot utilization) and then premiums were calculated as the difference between the PC sale price and auction price. The average of the premiums over the six market years was calculated and reported in figure 3.

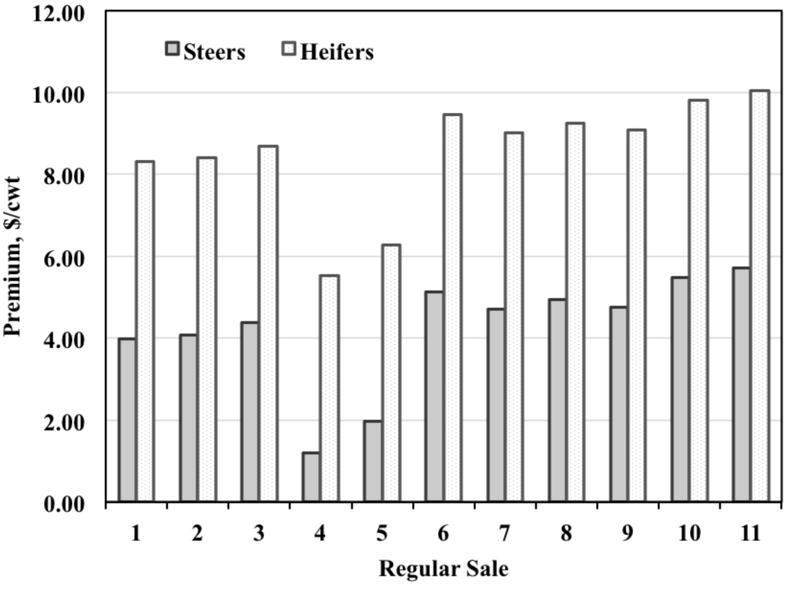

Figure 3. Estimated Preconditioned Sale Premium versus Location, Six-Year Average

the exception of *RegularSale*4 and *RegularSale*5, where the PC sale premiums are considerably lower compared to other locations. Furthermore, the premiums for preconditioned heifers have been significantly higher than for steers. In some cases, this may be due to preconditioned heifers not being purchased as feeders but as replacement animals.

As shown in figure 2, the value of preconditioning calves depends upon the selling weight, but it also varies seasonally. Figure 4 shows the predicted prices for steer calves sold in the PC sale versus regular sales at three weights (mean – std, mean, mean + std) by month of sale. The premiums (difference between PC and regular sales) are greater for lighter weight calves sold earlier in the market year. Prices for heavier calves sold in February are essentially equal (i.e., there is no premium for the PC sale). This result is not surprising as heavier calves sold later in the market year (e.g., February) are somewhat "preconditioned" even if they are not certified as preconditioned. That is, expectations would be that these calves are past the weaning stress period (i.e., weaned in excess of forty-five days) and are bunk adjusted. Thus, there is likely much less difference between non-preconditioned versus preconditioned calves in February than there is for lighter weight calves earlier in the marketing year.

With the exception of the 2012–13 market year, average premiums for PC calves have been increasing over time. Figure 5 reports the average premium (versus the eleven regular sales) as well as the premium versus the average of the two top and bottom auction prices. Compared to the top two auctions, there was one year in which there was no premium for selling calves in the PC sale and another two years where the premium was less than $1/cwt for steers. The premium compared to the average of all auctions ranged from $1.71 to $7.44/cwt for steers and $6.03 to $11.76/cwt for heifers over the six-year period.

Figure 6 displays the predicted steer prices versus feedlot capacity utilization levels across the entire data period (other variables at their means for 2013–14). The three levels of small feedlot utilization included (i.e., 50.1%, 54.4%, and 58.6%) are the mean +/- two standard deviations. Likewise, the scale on the x-axis for large feedlot capacity utilization reflects the same range (mean +/- 2 std). As large feedlot capacity utilization increases, prices decrease and then increase. Increasing capacity utilization from 50.7% to 58.3% results in a price decrease of slightly over $3/cwt. This compares to a price increase of over $17/cwt when capacity utilization increases from 58.3% to 81.3%. Higher prices when utilization is low are consistent with the expectations that large

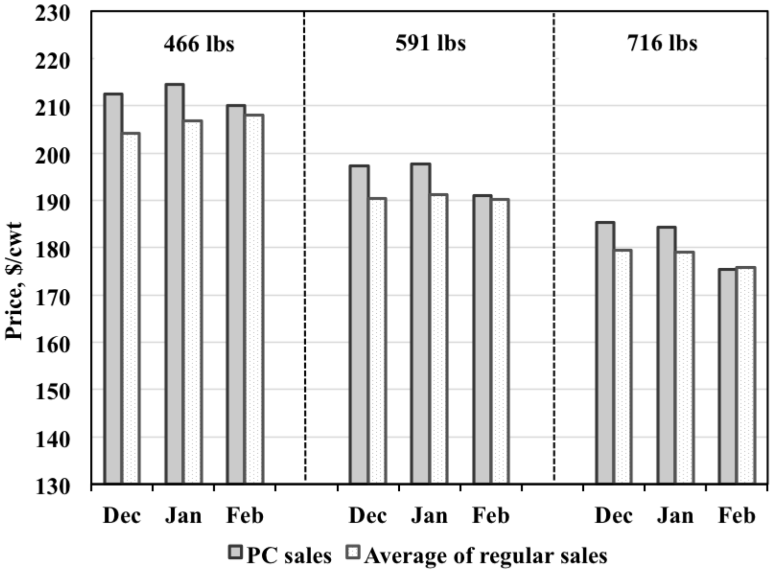

Figure 4. Estimated Steer Price versus Month, Weight, and Sale, 2013–14

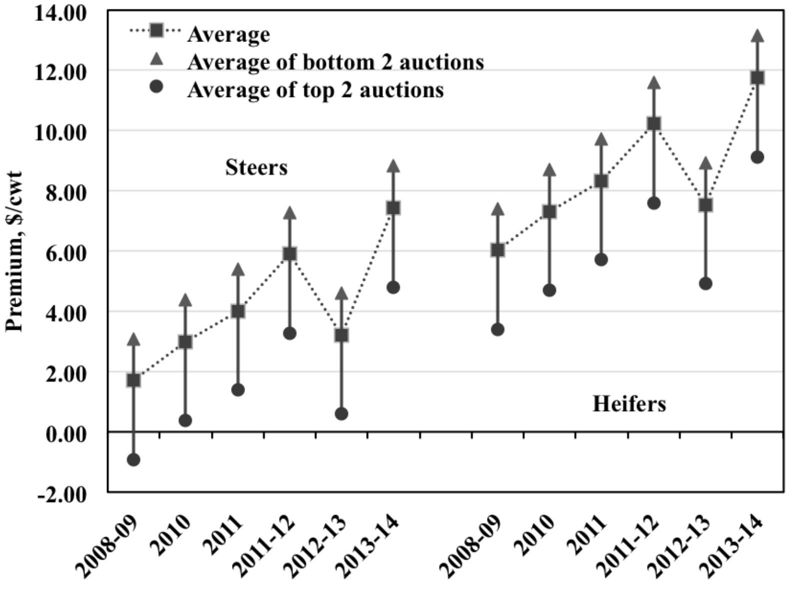

Figure 5. Estimated Preconditioned Sale Premium versus Market Year

feedlots likely bid more aggressively to procure cattle to offset fixed operation costs. However, the higher prices at high capacity utilization is less intuitive but likely reflects periods when expected profitability is high; thus feedlots continue to bid higher prices (i.e., increased profitability sends a signal, and economic incentive, to have more cattle to sell). In the case of small feedlot capacity utilization, prices were lowest when utilization was at a low level (mean −2 std), however, prices increased considerably at the mean and high utilization. Lower prices when small feedlot capacity utilization is low is consistent with buyers being farmer-feeders that may stay out of the market at

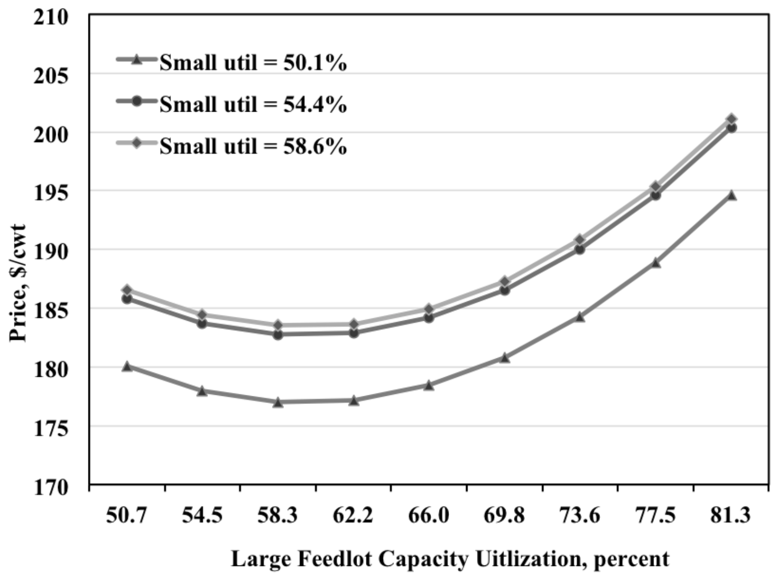

Figure 6. Estimated Steer Price versus Feedlot Capacity Utilization, 2013–14

times, lowering overall demand. As small feedlot capacity utilization increases to the mean and a high level (mean +2 std), prices increase, consistent with the result for large feedlots.

Preconditioned Sale

Table 5 shows the results for the preconditioned sale model. Figure 7 shows the estimated coefficients for the individual sellers. The range in coefficients, relative to a base seller, is approximately $20/cwt, indicating producers receive considerably different prices for their preconditioned calves after accounting for cattle characteristic and market variables included in the model. Of the 189 seller coefficients, only 40 (21%) are statistically different from 0 at the 10% level (this result varies based on which seller is used as the reference transaction). This result suggests a reputation effect (positive or negative) likely exists for some sellers. However, the majority of sellers receive comparable prices after accounting for the characteristics of their cattle and sale and market conditions.

Medium- and large-framed calves brought a significant premium ($5.10/cwt) relative to medium-framed calves. Lots with a muscle score of 1–2 brought a significant discount ($3.85/cwt) relative to lots with a muscle score of 1. As expected, cash prices are positively related to feeder cattle futures prices. For every $1/cwt increase in futures price, cash prices increase $1.17/cwt.

The impact of lot size is for increasing prices at a decreasing rate—the optimal lot size is 26 head (the mean lot size in PC sales was approximately 7 head and ranged from 1 to 48). Calves sold certified with a gold-tag received a $2.15/cwt discount relative to calves certified with a green tag. Thus, the added expense of the second round of vaccinations and weaning for a minimum of forty-five days (compared to a minimum of thirty days for the green-tag program) does not appear to be valued by buyers. This statistically significant discount does not make intuitive sense and is likely due to gold-tag calves being correlated with an unobservable factor negatively related to price. For example, gold-tag calves may appear fleshier when they are preconditioned (on feed) for at least an additional fifteen days, and the discount is due to the calf condition as opposed to the gold-tag program. Another possibility is that buyers may incur additional costs (e.g., sorting cattle) by deviating from their existing programs built around the "one vaccination" green-tag program. Unfortunately, we do not have the data to test these hypotheses. Additionally, the gold-tag program

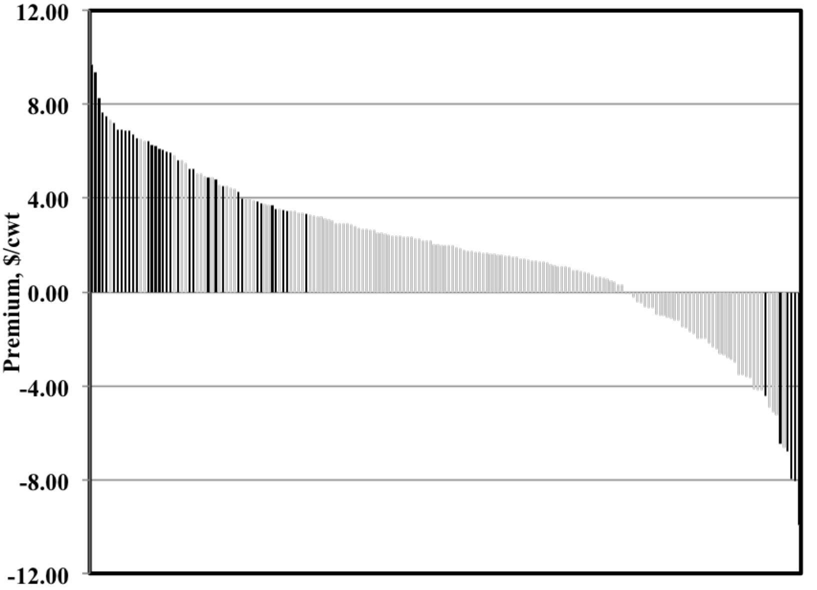

Figure 7. Estimated Seller Premium, Six-Year Average
Notes: Coefficient estimates compared to base seller. Black bars indicate statistical significance at the 10% level.

has only existed since the 2004–05 market year, while the green-tag program has existed since the 1970s. Perhaps newly launched preconditioning programs take time to build recognition and reputation. If and when this preconditioning program will be successful in garnering a premium over the green-tag program is unknown.

All hair coat colors received discounts relative to solid black cattle; however, not all were statistically significant. Those that were statistically significant at the 10% level were shades of yellow and/or white ($2.67/cwt) discount and red and white ($4.49/cwt discount). Lots classified by the Iowa State University recorder as being unhealthy ($\sim 1\%$ of lots) received discounts of $11.94/cwt.

Weight and seasonality results of the PC sale only model are generally similar to what was presented in the previous section. That is, prices decrease with increasing weight and are higher in December and January than in February. The price-weight relationship is slightly different in that prices decline at an increasing weight. This is likely because the value of a preconditioned calf will be higher at lighter weights, thus buyers decrease the price for heavier cattle at a slightly faster rate than regular auction cattle.

The results pertaining to feedlot capacity utilization were very similar to the previous section. That is, as large feedlot capacity utilization increases, prices decrease slightly and then increase. In the case of small feedlot capacity utilization, prices were the lowest when utilization was at a low level (mean -2 std), however, prices increased considerably at the mean and high (mean $+2$ std) utilization levels.

Application of Results

The main goals of this paper are two-fold. The first goal is adding understanding to the literature on feeder-calf price determinants by estimating hedonic models of transaction prices. The second goal is providing the cattle industry, especially producers, with information that allows them to make informed management and marketing decisions. However, because of the various interaction terms and nonlinear variables in the estimated models, users of this information cannot simply look at the

Table 6. Application of Preconditioned and Regular Sale Transactions Model Results

Sale Type-Location	Regular-3	PC Sale	PC Sale	PC Sale
Selling month	December	December	January	February
Sex	Steer	Steer	Steer	Steer
Frame size	Medium and Large	Medium and Large	Medium and Large	Medium and Large
Muscle score	1	1	1	1
Weight	600	600	645	690
Price, $/cwt	$189.39	$196.37	$191.55	$178.39
Price, $/head	$1,136	$1,178	$1,235	$1,231
Premium, $/cwt	base	$6.98	$2.16	−$10.99
Marginal premium, $/cwt			−$4.82	−$13.15
Premium, $/head	base	$41.89	$99.16	$94.59
Marginal premium, $/head			$57.28	−$4.57
Value of gain, $/cwt	base	n/a	$220.37	$105.10
Marginal value of gain, $/cwt			$127.28	−$10.16

Notes: All other independent values evaluated at means of the 2013–14 market year.

estimated coefficients for guidance. Rather, the estimated coefficients need to be used in a predictive way such that they have more value in making management and marketing decisions.

To demonstrate how the estimated hedonic models might be used to help producers make management and marketing decisions, consider the example of medium- and large-framed, muscle score 1, steer calves weaned in early November to be sold in December. After roughly thirty days of backgrounding, steer calves are expected to weigh 600 pounds. A producer is interested in knowing if it is worth the expense of preconditioning the calves versus selling them at a regular auction (with the distance to PC sale and regular sale location 3 being roughly equal). Further, the producer wants to know, if they choose to precondition the calves, whether they should feed them to January or February rather than sell them in December, assuming they will gain 1.5 pounds per day. To evaluate these decisions, model coefficients reported in table 4 are used to generate predicted prices (all other independent variables are held constant at means from the 2013–14 market year).

Table 6 reports model-predicted prices and respective marginal values for the scenario outlined above. The first column represents selling calves through a regular auction sale, and the next three columns reflect selling preconditioned calves in December (same as regular auction calves), January, and February, respectively. Preconditioned calves sold in February receive the lowest price/cwt, but generate the about the same revenue per head as calves sold in January due to the increased selling weight. Similarly, preconditioned calves sold in January weighing 645 pounds would be expected to receive a lower price/cwt than 600 pound preconditioned calves sold in December. However, they still bring an expected premium of $2.16/cwt over non-preconditioned calves sold in December at the regular auction. If a producer can precondition calves (i.e., provide them vaccinations and other required practices) for less than $41.89/head, they will be better off preconditioning calves rather than selling them through the regular auction. Furthermore, if they can feed them for an extra thirty days for less than $57.28/head ($127.28/cwt), they should market them in January rather than December. For calves sold in February compared to in January, the marginal gain is negative (-$10.16/cwt), indicating the producer would be better off selling the preconditioned calves in January as opposed to feeding them an additional thirty days and marketing them in February.

The results presented in table 6 were based on the model coefficients reported in table 4 (which are estimated from preconditioned and regular sales). However, conditional upon a producer deciding to precondition calves, results reported in table 5 (model estimated with preconditioned sales only) might be more appropriate to use for making management and marketing decisions.

Table 7. Application of Preconditioned Sale Model Results

Sale type-location	PC Sale	PC Sale	PC Sale
Selling month	December	January	February
Sex	Steer	Steer	Steer
Frame size	Medium and Large	Medium and Large	Medium and Large
Muscle score	1	1	1
Weight	600	645	690
Price, $/cwt	$192.85	$186.59	$174.23
Price, $/head	$1,157	$1,204	$1,202
Premium, $/cwt	base	−$6.26	−$18.62
Marginal premium, $/cwt			−$12.36
Premium, $/head	base	$46.41	$45.10
Marginal premium, $/head			−$1.31
Value of gain, $/cwt	base	$103.13	$50.11
Marginal value of gain, $/cwt			−$2.91

Notes: All other independent values evaluated at means of the 2013–14 market year.

Table 7 reports similar results as table 6 but focuses on preconditioned calf scenarios, and—while the numbers vary—the general conclusions are the same except in the case of very high feeding costs. That is, the producer should consider marketing preconditioning calves in January (as opposed to December), but feeding them until February will lead to lower expected returns.

The preceding example shows how information from this research can be used to help make management and marketing decisions and, more importantly, demonstrates that simply looking at reported coefficients is not sufficient for drawing conclusions given the interrelated and nonlinear relationships that exist between feeder-calf characteristics and prices.

Conclusions

This study adds empirical evidence to the literature on feeder-calf price differentials. In some cases the results validate previous results, and in other cases they provide new information that has not been previously reported. Some results from this study are consistent with previous findings in that we find feeder cattle prices are positively related with larger lot sizes, prices decline at a declining rate as cattle weight increases (i.e., weight-price slide exists), heifers bring lower prices than steers, prices for black-hided calves are either similar or higher relative to those of other colors, seasonality exists, and premiums for preconditioning exist and have been increasing somewhat over time. McNeill (2001) suggests that over time the beef industry has gained a better understanding of how calf weaning, preconditioning, and health programs affect efficiency and performance during growing, finishing, and slaughter phases of beef production. As a result, cattle feeders are more aware of the potential value of preconditioned calves and willing to pay higher prices for these calves.

Previous research typically identifies a premium associated with preconditioning, but here we show that the premium declines as cattle weight increases and also as calves are marketed later in the year (i.e., further from weaning time). This result is not unexpected, but it is important to quantify so that producers can make optimal management and marketing decisions. Unlike previous research, results here suggest a significantly higher premium for preconditioned heifers relative to steers. This finding is likely related to a time when producers may have been looking at preconditioned calves as replacement females for rebuilding herds and reinforces the importance for research to validate previous results and be updated as conditions and markets change.

Another new contribution of this research is our effort to quantify the impact that feedlot capacity utilization has on feeder-calf prices. Prices are found to be more sensitive to changes in large feedlot capacity utilization than they are for changes in small feedlot utilization. This is not consistent with expectations that large feedlots with a higher fixed cost structure will be in the market more consistently than small feedlots. To the extent that small feedlots tend to be more farmer-feeders, they would be expected to be "in and out" of the market more often, which will impact prices more than large feedlots that are consistently in the market.

Because this is the first study that we are aware of using feedlot capacity utilization data, it is difficult to ascertain the robustness of these results. Nonetheless, as a test of one particular hypothesis with implications for producer's management and marketing decisions, our empirical model provides fodder for the discussion of the effect of feedlot capacity utilization on feeder-calf prices that extends beyond market force measures typically examined in the literature. Given the excess capacity utilization in the industry, it is important for continued research in this area.

Seller reputation has been documented previously for purebred bulls but generally not considered for feeder cattle due to data availability. This research was able to examine seller reputation in preconditioned calf sales. After accounting for cattle, lot, sale, and market characteristics, roughly 79% of the lots sold brought statistically similar prices, but 21% received prices that were statistically different (18% higher and 3% lower) from the base seller in our model, indicating a seller reputation likely exists for some producers. The implication is that while most research has concluded that premiums exist for preconditioning calves, this will not necessarily be true for all producers (i.e., some producers will incur more costs and may not receive any premiums). Related to seller reputation, it might be that "sale" or "program" reputation matters, as gold-tag certified calves receiving two rounds of vaccinations and weaned for forty-five days did not bring a premium over the more commonly known green-tag program. This is another example of research that likely will need continued evaluation and replication to determine robustness of the results.

As previously stated, the goals of this research were to add understanding to the literature on feeder-calf price determinants and provide information to people in the cattle industry that allows them to make informed management and marketing decisions. Our goals were met through estimating hedonic models based upon transaction-level data from Iowa regular auctions and a preconditioned sale, and using estimated coefficients from these models for predicting prices as a function of cattle characteristics, management practices, and market conditions.

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