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The Influence of Market Power and Market Trends on Grid Market Signals

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This article investigates the premium and discount incentive mechanisms in the fed cattle grid pricing system. A pooled cross-sectional dataset containing carcass information on 598 fed steers evaluated weekly on the AMS publically reported price grid was constructed for the years 2001 to 2008 (226,000 observations). Empirical evidence suggests that premiums and discounts associated with specific carcass-quality attributes have been adjusting over time and that the market value of carcass quality declined by $0.50/cwt during periods of packer cooperative behavior in the fed cattle market. Additionally, the average market value of carcasses meeting industry quality standards exhibited a positive time trend.

Key words: carcass quality, fixed effects, grid pricing, oligopsony, pooled cross-sectional data, price transmission, random effects

Introduction

Various studies in the grid pricing literature have focused on the incentive structure associated with marketing on a grid (see Fausti et al., 2010, for a discussion of this literature). A subset of these studies has investigated how effectively the grid premium and discount incentive mechanism has performed as an information transmission mechanism (e.g., Feuz, 1999; Fausti and Qasmi, 2002; Johnson and Ward, 2005, 2006; Fausti et al., 2014). To date, a long-run empirical study of grid premium and discount behavior has not been conducted for the post-MPR (Livestock Mandatory Price Reporting Act of 1999) era.

The issue of packer market power in the slaughter cattle sector has been a popular area of study for economists. Empirical studies in this area have developed both long-run and short-run models to investigate packer market power in the meatpacking industry and the fed cattle market (e.g. Azzam and Anderson, 1996; Ward, 2010). However, the empirical grid pricing literature has not addressed the issue of how market structure may influence the grid incentive mechanism. The issue of packer market power influencing fed cattle producer grid marketing decisions has been discussed in the theoretical grid-pricing literature by Whitley (2002) and Fausti, Wang, and Lange (2013). No empirical investigation of whether oligopsony power influences grid premium and discount levels has appeared in the literature.

This research determines how the grid pricing structure has evolved as a market-signaling mechanism in the post-MPR era and whether packer market power has influenced market valuation of carcass quality attributes when cattle are sold on a grid. To do this, the long-run trends in the weekly market value of an animal's carcass quality attributes are analyzed in conjunction

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with identified periods of packer cooperative versus non-cooperative behavior (Cai, Stiegert, and Koontz, 2011). A linear mixed-modeling approach that encompasses both fixed and random effects is employed to identify factors influencing the market valuation of carcass quality within a grid pricing mechanism.[1]

The innovative aspect of this research is that it provides insight on the long-run economic relationships with respect to packer market power, market valuation of carcass quality attributes, and grid price signals. This is accomplished by evaluating the grid incentive mechanism using an animal's assessed premium or discount relative to a grid's base price over a seven-year period. Following the approach of Fausti and Qasmi (2002) and Fausti et al. (2014), the distinctive characteristic of the dataset is that carcass quality characteristics are held constant across time. Thus, market prices are the sole source of weekly variation in carcass value. This feature allows the long-run dynamic effect of grid premiums and discounts on individual carcass quality attribute valuation to be evaluated.

Two extensive fields of literature are associated with this study: meatpacker behavior in the fed cattle market and the evolution of the grid pricing mechanism for fed cattle. Ward (2010) provides a general overview of the issues and research on the beef industry's industrial structure. Fausti et al. (2010) provides a discussion of the grid-pricing literature. To optimize space, the discussion will focus on contributions germane to the issues addressed in this study.

Meatpacker Conduct when Purchasing Fed Cattle

The empirical literature on meatpacking market conduct can be divided into long- and short-run behavioral studies. Long-run behavioral studies on the fed cattle market have followed structure-performance approaches (e.g. Menkhaus, St. Clair, and Ahmaddaud, 1981) and conjectural variation approaches (e.g. Schroeter, 1988). Short-run empirical behavioral studies are based on game-theory predictions of cooperative versus non-cooperative firm behavior within an oligopoly market structure (e.g. Koontz and Garcia, 1993, 1997; Carlberg, Hogan, and Ward, 2009; Cai, Stiegert, and Koontz, 2011).[2] The short-run approach evaluates the change in packer margins to identify cooperative and non-cooperative short-run behavior in the slaughter cattle market. The implications drawn from this literature are that oligopsony behavior in the slaughter cattle market is intermittent and the degree of market power varies across time.

To determine whether there is evidence of oligopsony market power in the grid pricing system, the empirical models use the empirically estimated periods of cooperative and non-cooperative market power in the fed cattle market identified by Cai, Stiegert, and Koontz (2011) for the post-MPR period. Their empirical model is derived from the theoretical underpinnings of a branch of the industrial organization literature commonly referred to as "new empirical industrial organization" (Carlberg, Hogan, and Ward, 2009). Cai, Stiegert, and Koontz (2011, p. 608–11) present theoretical and empirical models based on firm behavioral assumptions outlined in Mailath and Samuelson (2006) for a multiple-player dynamic game. Cai, Stiegert, and Koontz (2011) use a Markov regime-switching model to estimate packer margins that provide approximations for dating and duration of cooperative and non-cooperative regimes in the fed cattle market (p. 615).

This literature is extended by empirically testing whether market power affects the market valuation of a slaughter animal's carcass quality attributes by incorporating the periods identified by Cai, Stiegert, and Koontz (2011, table 3/figure 2) into the empirical analysis as cooperative and

[1] In the mixed-model procedure, the model accounts for both means and variances of the data. Fixed effects refer to mean-level parameter estimates (β) and random effects refer to covariance parameter estimates (γ). In addition, this method allows blocking by subject and controls for within-subject correlation effects on the standard error with respect to repeated measures of the dependent variable. This approach also provides flexibility by allowing for the introduction of random parameter estimates for time-varying exogenous variables. See Allison (2005) for a more detailed discussion.

[2] In this literature, cooperative behavior refers to a market where only a small number of firms operate and coordinate pricing and output strategies in order to earn economic rent. Non-cooperative behavior refers to the aforementioned market structure where firms behave competitively.

non-cooperative behavior using a bivariate dummy variable. It is assumed that the market power price effect varies randomly across animals and time. The random-effects assumption is consistent with the literature's conclusion that oligopsony behavior in the slaughter cattle market is intermittent and the degree of market power varies across time.

Carcass Quality Attributes and Grid Price Transmission

The value-based marketing initiative (National Cattlemen's Association, Value-Based Marketing Task Force, 1990) was the beef industry's response to declining beef demand, which began to decline in the late 1970s, bottomed out in the late 1990s, and has not yet fully recovered to peak demand (Schroeder et al., 1998; Fausti et al., 2010). The goal of the National Cattlemen's Association initiative was to increase beef demand by improving the overall quality of beef carcasses and improving production efficiency along the beef supply chain. Grid pricing of fed cattle is a key component in the beef industry's value-based marketing initiative. The beef industry identified the practice of selling fed cattle by the pen at an average price as a significant source of inconsistency in carcass quality and a factor associated with weak beef demand (Fausti, Feuz, and Wagner, 1998).

The grid-pricing literature has documented that the outcome of selling cattle based on individual carcass merits is dependent on carcass quality. Therefore, the price when selling on a grid can be either above or below the pen average price when cattle are sold based on live or dressed weights (e.g. Feuz, Fausti, and Wagner, 1993; McDonald and Schroeder, 2003). Ward (2005) shows that packers consistently pay more (less) for high-quality cattle when purchased on a grid (live weight by the pen) relative to mid-quality cattle purchased by dressed weight. Conversely, price variability increases when selling on a grid, regardless of cattle quality (e.g. Fausti, Feuz, and Wagner, 1998; Schroeder and Graff, 2000; Anderson and Zeuli, 2001; Feuz, Fausti, and Wagner, 1995).

A number of studies have investigated the properties of the grid-pricing method as a price-transmission mechanism for market preferences with respect to specific carcass quality attributes (Feuz, Fausti, and Wagner, 1993; Feuz, 1999; Schroeder and Graff, 2000; Fausti and Qasmi, 2002; Johnson and Ward, 2005, 2006; Fausti et al., 2014). The general consensus of the literature is that grid pricing mechanisms transmit market preferences for carcass quality. However, the grid pricing system seems to have a bias toward discounts. This literature suggests that the incentive of grid premiums may not be strong enough to overcome the financial risk associated with grid discounts to induce a majority of fed cattle producers to sell their cattle on a grid (Fausti and Feuz, 1995; Fausti, Feuz, and Wagner, 1998; Fausti and Qasmi, 2002; Johnson and Ward, 2005, 2006). Thus, it is argued in the aforementioned literature that the discount bias represents a barrier to adoption by producers. In a recent study, Fausti et al. (2014) report empirical evidence that this negative bias is weakening.

This literature is extended by empirically estimating the effect of the adjustment in grid premiums and discounts over time on the valuation of carcass quality attributes. To date, the long-run dynamic effect of grid premiums and discounts on individual carcass quality attribute valuation has not been addressed.

The empirical extension is accomplished by adopting a grid pricing methodolgy introduced by Feuz (1999, p. 333–34). Feuz's equation (5) encompasses an individual carcass's grid premium or discount per hundredweight. A simplification of equation (5) yields Feuz's "value based price premium" (VBP). The version of the VBP used here follows the refinements discussed in Fausti, Feuz, and Wagner (1998), in which they suggest using the AMS additive grid to derive VBP estimates for individual dressed-weight carcasses.

This extension of the Feuz approach allows an evaluation of a single set of slaughter steers over an extended time period. It is hypothesized that the influence of the interaction of an animal's carcass quality attributes and a grid's incentive mechanism on VBP can be revealed by identifying the dynamics of the market on carcass valuation over time.

Table 1. Cattle Quality Characteristics and γ_i Estimates: (N=598)

Variable	Mean	Std Dev	Minimum	Maximum
HCW	743.19	74.25	579.00	991.00
Dress	60.68	2.08	53.09	69.70
REA	12.55	1.44	8.10	20.30
FT	0.43	0.18	0.10	1.10
KPH	1.87	0.60	0.50	3.50
Marb	493.09	91.65	340.00	830.00
YG	2.75	0.75	0.56	5.24
QG	2.52	0.64	1.00	4.00
γ_i	0.00	0.48	−0.81	0.55

Notes: HCW is hot carcass weight; *Dress* is animal dressing percentage; *REA* is rib-eye area; *FT* denotes fat thickness over the seventh rib; *KPH* is kidney-pelvic-heart fat measurement; *MARB* is marbling score; *YG* denotes USDA quality grade score; *QG* is USDA yield grade score; and *gamma*$_i$ denotes the OLS parameter estimate for the effect of *MP* on individual steer VBP.

Table 2. Beef Packing Industry Cooperative Time Periods

Cooperative Period	Period (weeks)	Start Date	End Date
*MP*1	0<weeks<39	04/09/01	12/26/01
*MP*2	53<weeks<81	04/15/02	10/14/02
*MP*3	106<weeks<150	04/21/03	02/09/04
*MP*4	157<weeks<168	04/12/04	06/21/04
*MP*5	206<weeks<220	03/21/05	06/13/05
*MP*6	241<weeks<283	11/21/05	08/28/06
*MP*7	299<weeks<324	01/01/07	06/18/07
*MP*8	367<weeks	04/12/08	06/21/08

Data

A pooled time series, cross-sectional dataset containing carcass information on fed steers evaluated weekly on the USDA-AMS publically reported price grid (National Carcass Premiums and Discounts for Slaughter Steers and Heifers) was constructed for the years 2001 to 2008. The animal data contain carcass characteristics for 598 slaughter steers (see table 1) collected by the Animal Science Department at SDSU as part of a ranch-to-rail study (Fausti et al., 2003).

The price data were collected from USDA weekly grid premium and discount reports. Using the additive premium and discount price grid, the price data were used to simulate individual animal weekly per head VBP using the AMS price grid data from April 2001 to June 2008. The AMS weekly reported Nebraska dressed-weight price (35% to 65% Choice) was collected to represent the general price level for the slaughter cattle market (Nebraska Weekly Direct Slaughter Cattle-Negotiated Purchases). Price data are combined with individual animal carcass characteristics. A total of 378 weeks of price data were simulated. The dataset thus contains 226,044 observations.

The dating of meatpacker cooperative versus non-cooperative behavior periods is based on estimates of cooperative behavior duration by Cai, Stiegert, and Koontz (2011, p. 615, table 3), who determined that there were eight cooperative periods that occurred between 2004 and 2008. These periods are listed in table 2. In table 3, the bivariate dummy representing cooperative periods, periods with market power (MP), has a mean of 0.548, indicating that during the period of our study cooperative regime behavior occurred approximately 55% of the time.

Summary statistics presented in table 3 indicate that 52.21% of the 598 carcasses graded Choice, 39.6% graded Select, 6.85% graded Standard, and 1.34% graded Prime. Carcasses receiving a yield grade of less than 2 accounted for 17.2% of the sample. Yield grades 2 to 3 accounted for 48.3%, and 6% received a yield grade of 4 or greater. Yield grades 3 to 4 accounted for 28.5% of the sample.

Table 3. Summary Statistics: VBP Dataset (N=226,044)

Variable	Mean	Std Dev	Minimum	Maximum
VBP (dependent)	−4.87	6.78	−44.43	15.28
$QS1$	0.24	0.43	0.00	1.00
$QS2$	0.27	0.45	0.00	1.00
$QS3$	0.24	0.43	0.00	1.00
$Time$	189.50	109.12	1.00	378.00
$Prime$	0.01	0.12	0.00	1.00
$Choice$	0.52	0.50	0.00	1.00
$Select$	0.40	0.49	0.00	1.00
$Standard$	0.07	0.25	0.00	1.00
$YG1$	0.17	0.38	0.00	1.00
$YG2$	0.48	0.50	0.00	1.00
$YG45$	0.06	0.24	0.00	1.00
HWT	0.01	0.10	0.00	1.00
LWT	0.02	0.15	0.00	1.00
P_t	131.31	15.89	97.80	172.46
MP	0.55	0.50	0.00	1.00

Carcasses determined to be either heavyweight or lightweight accounted for 1% and 2% of the carcasses graded, respectively. The per hundredweight premium/discount variable (VBP) averaged -$4.87.

Methodology

A pooled time-series regression model is employed to analyze how the market valuation of carcass quality characteristics has changed over time. The levied premium or discount, VBP, is regressed on dummy variables reflecting individual steer carcass quality levels based on categories defined by the AMS grid. Quarterly dummy variables are included to account for seasonality. A bivariate dummy variable, MP, reflects periods of packer cooperative behavior. Additional covariates include a time-trend variable, interaction terms, and the weekly hot carcass dressed-weight price.

A linear mixed model (LMM) is adopted: $VBP = \boldsymbol{X}\beta + \boldsymbol{Z}\gamma + \varepsilon$ (SAS Institute, Inc., 2011). The dependent variable (VBP) denotes the vector of dependent variable observations. Matrix $\boldsymbol{X}$ is the known design matrix associated with $\boldsymbol{\beta}$, which represents the vector of unknown fixed-effects parameters. Matrix $\boldsymbol{Z}$ is the known design matrix associated with $\gamma \sim \boldsymbol{N}(O, \boldsymbol{G})$, representing the vector of unknown random-effects parameters. The error term, denoted $\varepsilon \sim \boldsymbol{N}(O, \boldsymbol{R})$, reflects an unknown random error vector. It is assumed that γ and ε are independent.

Matrices $\boldsymbol{G}$ and $\boldsymbol{R}$ are the covariance matrices associated with γ and ε, respectively. The mixed procedure requires the covariance matrices $\boldsymbol{G}$ and $\boldsymbol{R}$ to be specified. A variance components specification is used for $\boldsymbol{G}$ and a blocked (subject-dependent) first-order autoregressive specification is used for $\boldsymbol{R}$. These specifications are based on regression diagnostics.

The specific functional form of a mixed-effects model selected to analyze the data is

$$VBP_{it} = \alpha + \sum_{j=1}^{8} \beta_j C_{ijt} + \sum_{i=1}^{598} \gamma_i Z_{it} + \delta T_t + \sum_{k=1}^{3} \theta_k S_{ikt} + \sum_{j=1}^{8} \phi_j C_{ijt} T_t + \omega P_t + \rho P_t T_t + \vartheta MP_t + \varepsilon_{it}, \quad (1)$$

where $i = 1, \ldots, 598$; $j = 1, \ldots, 8$; $k = 1, \ldots, 3$; and $t = 1, \ldots, 378$.

where VBP_{it} denotes the individual animal's weekly grid determined carcass quality attribute valuation (defined in terms of dollars per hundredweight); C denotes individual time-invariant[3] animal carcass quality characteristics; T denotes the time trend variable; S denotes the seasonal quarterly dummy variables; P denotes the AMS-reported Nebraska dressed-weight price (HCWP); MP denotes a fixed-effects bivariate dummy variable representing cooperative and non-cooperative periods; $\mathbf{Z}$ is the design matrix associated with γ, the random-effects parameter estimate for MP; and ε is as defined above. Subscripts denote matrix dimensions: i denotes the number of subjects, j denotes the number of carcass quality dummy variables, t denotes the number of time periods, and k denotes the number of seasonal dummy variables. Parameters α, β, θ, δ, ϕ, ω, ρ, and ϑ represent fixed effects and γ denotes the random-effects parameter estimate.

Fixed- and Random-Effects Variables Defined

Quarterly seasonal dummy variables were constructed, with October through December designated as the base quarter. There is also a weekly time trend variable. Based on Cai, Stiegert, and Koontz (2011), a bivariate dummy variable is constructed representing packer cooperative ($MP = 1$) versus non-cooperative periods ($MP = 0$). The MP variable was also selected as the random-effects variable to test the Cai, Stiegert, and Koontz (2011, p. 625) conclusion that "estimates of regime-dependent variances, p_1 and p_2, are significant and vary across regimes." Thus, the MP fixed-effects estimate is the average effect across all subjects (steers) and the random-effects assumption produces unique estimates for individual steers.

The variable P_t is included to determine whether a change in the market price for slaughter cattle affected how the market rewards carcass characteristics over time. Fausti and Qasmi (2002) hypothesized that such a relationship may exist between the P_t and grid premium and discount levels.

Carcass quality variable categories are based on marbling scores and kidney/pelvic/heart fat measurements and are then converted into dummy variables. Quality grade categories are Prime, Choice, Select, and Standard, with Choice as the base. Yield grade variable categories are yield grade less than 2 (YG1), yield grade greater than or equal to 2 and less than 3 (YG2), yield grade greater than or equal to 3 and less than 4 (YG3), and yield grade of 4 or greater (YG45). YG3 is designated as the base. The heavyweight carcass dummy variable (HWT) reflects a carcass with a hot carcass weight greater than 950 pounds and the lightweight carcass dummy variable (LWT) reflects a carcass with a hot carcass weight less than 600 pounds. Interaction terms combining the time trend variable with carcass traits are used to determine whether there is a trend in the market incentive mechanism for specific carcass quality attributes. An interaction term for P_t was also included to test whether the market price effect on grid premium and discount levels has been changing over time.

Model Diagnostics

The empirical analysis was conducted using SAS version 9.3. The mixed-effects model was estimated using SAS's Restricted Maximum Likelihood method. The LMM procedure in SAS provides great flexibility when dealing with regression diagnostic issues (SAS Institute, Inc., 1999). First, unit root tests were conducted for the two continuous variables in the model, VBP and P_t. The Phillips-Perron Unit Root Test (SAS Institute, Inc., 1999, Chapter 41, p. 332) indicated that both variables are stationary at a p-value of less than 0.001.

Next a "sandwich estimator" approach was employed to produce robust standard errors associated with parameter estimates (Diggle, Liang, and Zeger, 1994; SAS Institute, Inc., 1999, chapter 41). The default covariance structure for the mixed procedure is variance components

[3] The mixed-model specification allows for the inclusion of time-invariant explanatory variables that capture specific time-invariant effects.

Table 4. Variance Components Statistics and LMM Model Fit Statistics

Covariance Parameter	Covariance Parameter Estimate & Z statistic
MP	0.2157: Z= 14.28
AR(1)	0.9626: Z= 1,688.4
Residual	8.3747: Z= 65.72
LMM Fit Statistics	
−2 Log Likelihood	534,260.7
AIC	534,266.7
BIC	534,279.9
Intraclass Correlation Coefficient	ICC_{MP} = 2.26%
	ICC_{AR1} = 10.08%
Likelihood Ratio Test: Unrestricted Model (Mixed-Effects *MP*) vs. Restricted Model (Fixed-Effects *MP*)	Likelihood Ratio Test Statistic=1,784.8
	Pr> ChiSq <.0001 with DF=1.

(SAS Institute, Inc., 1999, p. 2088).[4] Other covariance structures for $\boldsymbol{G}$ and $\boldsymbol{R}$ were investigated. The variance components structure was selected for matrix $\boldsymbol{G}$, and the autoregressive of order one structure was selected for matrix $\boldsymbol{R}$. Both covariance structure assumptions were based on the Null Model Likelihood Ratio Test. To test the random-effects assumption, the Likelihood Ratio Test compared the restricted model (fixed effects) versus the unrestricted model, which assumes that *MP* is a random effect. The test indicated that the random-effects assumption is valid at a p-value less than 0.001.[5]

Results

The variance components estimating procedure provided evidence that the variance associated with matrix $\boldsymbol{G}$'s contribution to the variance of VBP was statistically significant at the 1% level (table 4). The statistical significance of the random-effects covariance parameter estimate (table 4) and the Likelihood Ratio Test result justify the mixed-model assumption. Fit statistics for the LMM model are also provided in table 4.

Overview of Fixed-Effects Estimates

Type-3 tests indicate that all fixed-effects variables are statistically significant at a p-value less than 0.01. The fixed-effects intercept estimate is -\$0.84 (table 5), which represents the industry standard carcass, the default carcass quality in the empirical model. If all of the fixed-effect dummy variables are set to their default values—and assuming $t = 0$ and $P_t = \$100$—then a quality grade Choice, yield grade 3 carcass weighing 600–950 pounds will receive: $VBP = -\$0.84 + \$0.63 = -\$0.21$/cwt. At the other end of the time spectrum ($t = 378$) and $P_t = \$100$/cwt, the VBP for the industry standard carcass is estimated at: $-\$0.84 + \$0.63 + \$1.46 = \$1.25$/cwt. These anecdotal calculations suggest that the long-run trend reflected in the grid price signaling mechanism is positive for steer carcasses that meet the industry standard, a finding that is consistent with Fausti et al. (2014). Fixed-effects parameter estimates for the main and interaction effect variables are presented in table 5.

[4] The Likelihood Ratio Test indicated that variance components covariance matrix was superior to the OLS diagonal covariance structure ($\sigma^2\boldsymbol{I}$), where $\boldsymbol{I}$ is the identity matrix.

[5] The SAS mixed procedure does not have Haussmann option for testing fixed vs. random effects. An alternative is to test for unobserved heterogeneity by examining the assumption of Corr $(\boldsymbol{X}, \varepsilon) = 0$. All correlations between the residuals and covariates are less than 15%. Therefore, it is assumed the mixed model approach is valid.

Table 5. VBP REML Fixed-Effects Parameter Estimates

Variable	DF	Estimate	Std. Error	t Value	Pr > |t|
Intercept	23K	−0.8389	0.0663	−12.66	< 0.0001
$QS1$	23K	0.1526	0.0082	18.55	< 0.0001
$QS2$	23K	−0.2092	0.0099	−21.03	< 0.0001
$QS3$	23K	0.1999	0.0088	22.80	< 0.0001
$Time$	23K	0.0039	0.0004	9.27	< 0.0001
$Prime$	23K	4.7287	0.0540	87.51	< 0.0001
$Select$	23K	−7.9377	0.0256	−310.52	< 0.0001
$Standard$	23K	−16.7322	0.2711	−61.72	< 0.0001
$YG1$	23K	2.7584	0.0467	60.39	< 0.0001
$YG2$	23K	1.5183	0.0189	80.14	< 0.0001
$YG45$	23K	−13.3550	0.2246	−59.47	< 0.0001
HWT	23K	−9.1095	0.0640	−142.37	< 0.0001
LWT	23K	−3.5585	0.9774	−3.64	0.0003
P_t	23K	0.0063	0.0006	11.18	< 0.0001
$Time \times Prime$	23K	0.0167	0.0001	259.74	< 0.0001
$Time \times Select$	23K	−0.0036	0.0001	−85.52	< 0.0001
$Time \times standard$	23K	−0.0029	0.0001	−31.81	< 0.0001
$Time \times YG1$	23K	0.0004	0.0001	5.85	< 0.0001
$Time \times YG2$	23K	−0.0006	0.0001	−13.72	< 0.0001
$Time \times YG45$	23K	−0.0010	0.0001	−16.96	< 0.0001
$Time \times HWT$	23K	0.0132	0.0001	173.06	< 0.0001
$Time \times LWT$	23K	−0.0008	0.0003	−3.08	0.0021
$Time \times P_t$	23K	−0.00003	0.0001	−9.90	< 0.0001
MP	597	−0.4966	0.0209	−23.78	< 0.0001

Main Effects

All carcass-quality dummy parameter estimates have the expected sign (premium versus discount). The parameter values fall within the expected range, given the inclusion of the interaction terms. Quarterly seasonal dummy variable parameter estimates indicate that, relative to the fourth quarter, VBP increases in the first and third quarters and declines in the second quarter. The seasonality estimates are consistent with the literature (e.g. Fausti and Qasmi, 2002). The parameter estimate for P_t is positive and significant ($p<0.001$), indicating that while the market price for slaughter cattle is not directly related to VBP it does positively influence VBP. This finding supports the supply response hypothesis proposed by Fausti and Qasmi (2002, p. 31).

The market power dummy variable (MP) was negative and significant ($p<0.001$), indicating that during cooperative periods VBP declined by approximately $0.50/cwt relative to non-cooperative periods. For a dressed carcass weighing 800 pounds, this implies a reduction of $4.00 in per head revenue. This result supports the empirical work of Cai, Stiegert, and Koontz (2011) by presenting empirical evidence demonstrating that the packing industry generates oligopsony rents in the fed cattle market during cooperative periods. Furthermore, this result contributes to both strands of literature by providing evidence of oligopsony rents being extracted when slaughter cattle are sold on a grid during cooperative periods.

Indirect Fixed Effects

Interaction terms between T_t and C_{ijt}, and between T_t and P_t were also modeled. The interaction terms indicate that the quality characteristics of Prime and YG1 exhibit a positive trend in market value with respect to their influence on VBP over time. The quality characteristics of Standard, YG45, and LWT all exhibit a negative trend, suggesting that these carcass attributes experienced a deepening of the market discount during the period of the study. The carcass attributes of YG2 and HWT both had unexpected signs. The interaction term for yield grade 2–3 was negative, indicating the premium paid for this attribute has declined over time. The interaction term for HWT was positive, suggesting that this discount penalty has lessened over time. The parameter estimate for the Select carcass interaction term was negative, suggesting that the discount on Select quality grade carcasses deepened during this period.

Overall, the interaction terms indicate a pattern of intensification across grid discounts and premiums. This suggests a strengthening of market signals for specific characteristics. This is especially true with respect to the quality grade versus yield categories. The interaction parameter estimates for quality grade categories are an order of magnitude higher than for the yield grade categories.

The final interaction term estimated was for P_t. The parameter estimate was negative and statistically significant, but the low magnitude suggests the relationship between VBP and market price had a significant positive relationship overall. This suggests that the rising price of cattle played an important role in the positive change in VBP over the seven-year period.

Overview of Random-Effects Estimates

Oligopsony market power is hypothesized to represent a random-effects explanatory variable based on the work of Cai, Stiegert, and Koontz (2011). Using the variance components estimating procedure, the *MP* covariance parameter estimate associated with matrix $\boldsymbol{G}$ is statistically significant at less than 1%. This supports the supposition that there is variability in the level of persistence and intensity of oligopsony market power in the fed cattle grid pricing system (table 4).

The random-effects option in SAS also produces parameter estimates for γ_i. The fixed-effects parameter estimate for *MP* (−\$0.50) represents the average effect of oligopsony behavior for the group of 598 head during cooperative periods.[6] The parameter estimates for γ_i represent the estimated effect of cooperative periods on individual steers. Thus these estimates (not directly reported; summary statistics for γ_i are reported in table 1) reflect the marginal adjustment to the fixed-effects parameter estimate for *MP* due to differences in carcass quality attributes across the 598 steers.

An auxiliary OLS regression was used to gain insight on how cooperative periods affect the grid premium and discount structure. The γ_i parameter estimates were regressed on the carcass quality attribute dummy variables, C_{ij}:

$$\gamma_i = \alpha + \sum_{j=1}^{8} \beta_j C_{ij}, \text{ where } i = 1, \ldots, 598. \text{ (SAS Ver. 9.3)} \tag{2}$$

The model was tested for multicollinearity and heteroskedasticity. The Variance Inflation Factor (VIF) estimates were all less than 2. However, heteroskedasticity was detected and a White correction procedure was implemented to generate heteroskedasticity-consistent standard errors (White, 1980, p. 822). Those statistics and partial R-square estimates are also reported (table 6).

All of the explanatory variables were statistically significant and negative, except for Prime and YG1, which were positive (table 6). The estimated intercept (\$0.41) represents the adjustment to the fixed-effects (*MP*) parameter estimate for an industry standard carcass (Choice, YG3, 600–950 lbs.). This estimate suggests that packers extracted \$0.09/cwt in oligopsony rent during cooperative periods from carcasses meeting the industry quality standard. The positive coefficient for Prime (\$0.05) suggests that even Prime carcasses were subject to a small oligopsony rent (\$0.04) during the period covered in this study. This is surprising given that only a very small percentage of carcasses

[6] The fixed effects parameter estimate for MP represents a shift in the estimated intercept. The -\$0.50/cwt is an estimate of oligopsony rent during cooperative periods relative to non-cooperative periods. Cai, Stiegert, and Koontz (2011, p. 614) concluded that packers behaved competitively during non-cooperative periods in the post-MPR period.

Table 6. OLS Estimates of MP Random-Effects Coefficient Model

Variable	DF	Estimate	Std Error	t Value	Pr > |t|	Partial R^2
Intercept	1	0.4071	0.0016	249.28	<.0001	
Prime	1	0.0465	0.0073	6.35	<.0001	0.0002
Select	1	−0.8729	0.0020	−448.73	<.0001	0.7992
Standard	1	−0.7781	0.0036	−215.73	<.0001	0.1925
*YG*1	1	0.0413	0.0029	14.51	<.0001	0.0019
*YG*2	1	−0.0167	0.0021	−8.03	<.0001	0.0003
*YG*45	1	−0.1019	0.0038	−27.08	<.0001	0.0030
LWT	1	−0.0105	0.0058	−1.81	0.0715	0.0000
HWT	1	−0.1033	0.0084	−12.27	<.0001	0.0006

Notes: Model: DF=8, Sum of Sqs=106.5184, Mean Sq=13.3148, F value=31836.8, Pr> F <.0001
Error: DF=589, Sum of Sqs=0.2463, Mean Sq=0.0004
Root MSE=0.02005, R^2=0.9977

grade Prime and this carcass attribute is primarily purchased by white tablecloth restaurants; a very competitive niche market.

Parameter estimates for yield grade characteristics are statistically significant. Only the YG1 had a positive parameter estimate. This suggests that both yield grade premiums and discounts experienced downward pressure during cooperative periods. Both the LWT and HWT discounts were also negatively affected during cooperative periods.

Parameter estimates for Select and Standard carcasses indicate that quality grade discounts experienced the greatest pricing pressure during cooperative periods. The Select and Standard grade category discounts deepened by $0.87/cwt and $0.88/cwt, respectively. In addition, the partial R-square estimates indicate that Select and Standard grade categories explained 80% and 19% of the variability in γ_i, respectively (table 6). This finding is consistent with the literature on the importance of the Choice/Select spread in a grid pricing system (e.g. Ward, 2005). The remaining variables, combined, contribute less than 1% to the model's R-square.

The empirical evidence suggests that during cooperative periods, packing firms extracted oligopsony rent primarily through the grid discount structure. Within the grid discount structure, oligopsony rent was extracted primarily from the carcass quality grade discount categories. The empirical evidence further suggests that oligopsony pricing power focused primarily on the grid discount structure lends credence to a general complaint raised by producers that the grid system is a pricing system of discounts only (e.g. Fausti, Feuz, and Wagner, 1998; Johnson and Ward, 2005).

Summary and Conclusions

This study determined how grid pricing structure has evolved as a market signaling mechanism in the post-MPR era and whether packer market power has affected market valuation of carcass quality attributes when cattle are sold on a grid. With respect to the transmission of market signals, an approach suggested by Feuz (1999) is adopted. Empirical evidence suggests that, on average, a pattern of intensification across grid discounts and premiums has occurred over time. This trend has led to a general improvement in the market valuation of carcass quality attributes for the animals included in this study that met the industry standard for carcass quality. This positive trend suggests that the barriers to grid price adoption are weakening over time, but the grid discount structure continues to be an issue.

The other issue addressed was to determine whether oligopsony market power influenced the market valuation of slaughter cattle carcass quality attributes when cattle were sold on a grid. Work by Cai, Stiegert, and Koontz (2011) was extended by adopting their empirical duration estimates of cooperative meatpacker behavior. Identified periods of cooperative behavior were incorporated into the empirical model to test whether oligopsony market power affected an individual steer's carcass premium and discount. The empirical results indicate that, during periods of cooperative behavior, packers extracted oligopsony rents primarily through the deepening of carcass quality discounts. Thus, one could argue that oligopsony behavior during cooperative periods could pose a barrier to adoption for those producers who are uncertain about the quality of the cattle they are marketing.

The fed cattle slaughter volume pattern across marketing channels has shifted dramatically since 2008. According to Koontz (2013), slaughter volume patterns have moved away from the cash market and toward the formula contract market. Koontz shows that slaughter volume in the cash market has declined from around 50% in 2008 to under 30% in 2012. Formula pricing has risen from 40% to over 60% during the same period. This suggests a dramatic shift toward grid pricing given the prevalence of transactions based on grid pricing in the contract market. The empirical evidence presented in this study suggests that packers were able to extract economic rent through the grid discount structure. Given this empirical evidence, additional work in this area is needed to determine whether oligopsony behavior has intensified beyond the time period addressed in this study.

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