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Price and Market Behavior: Pricing Fed Cattle on a Grid

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Abstract

A seven year comparative study of grid pricing versus average pricing of slaughter cattle was conducted to evaluate carcass quality market signals. The primary objective of the study is to determine if market signals sent through the grid pricing system are encouraging producers to market on a grid and discouraging them to market by the pen. Two secondary objectives investigate: 1) if price risk associated with carcass quality uncertainty affects marketing decisions, and 2) if a change in price risk (volatility) affects producer marketing decisions.

An EARCH-In-Mean modeling procedure was adopted. Empirical results suggest that the grid premium and discount structure is slowly adjusting carcass quality market signals to encourage marketing on a grid and discourage marketing by the pen. The inclusion of the conditional variance in the empirical model indicates that risk associated with carcass quality uncertainty is a potential barrier to adoption of the grid pricing system by producers.

Keywords: carcass quality, EARCH, grid pricing, marketing, price risk

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Risk and Marketing Behavior: Pricing Fed Cattle on a Grid

The beef industry continues to recover from an extended period of relatively weak demand and declining market share for its product (Tonsor 2011). The beef industry has responded by promoting production and marketing reforms along its entire supply chain. The stated goal of these suggested reforms is to transform the beef industry into a value-based industry. The blueprint of this initiative is outlined in an industry sponsored white paper: *War on Fat* released by the Value Based Marketing Task Force (VBMTF 1990).

A key component of the initiative is the call for the development of a value based pricing system. In the early 1990s the industry began the conversion from the traditional "Grade and Yield" pricing system for fed cattle into what is commonly referred to as grid pricing. The goal of the beef industry's movement toward value based pricing is to improve the flow of information from the consumer to the producer so that the industry is producing the "right product at the right price to meet consumer demand" (Fausti et al. 2010a: p. 19).

The grid pricing literature (e.g., Schroeder and Graff 2000; Fausti and Qasmi 2002; McDonald and Schroeder 2003; Johnson and Ward 2005) has investigated and discussed in great detail the effectiveness of the grid pricing system to transmit market signals to producers with respect to carcass quality. This literature has also discussed potential barriers to across-the-board producer adoption of grid pricing (e.g., Fausti et al. 1998; Belasco et al. 2010). Several studies have attempted to estimate grid market share of fed cattle slaughter volume (e.g., Schroeder et al. 2002; Muth et al. 2007; Fausti et al. 2010a) to determine the level of industry adoption of the grid pricing system. However, up to this point, empirical evidence on if the incentive structure of the grid pricing system (since its inception) has become a more effective signaling mechanism with respect to carcass quality has not appeared in the literature.

The objective of this paper is to investigate if the effectiveness of the grid pricing system to transmit informative market signals to producers has changed over time. In this study, we evaluate grid market signals by comparing the financial incentive structure of the grid system to the producer's alternative of selling fed cattle by the pen at an average price.

The empirical analysis begins with two pens of cattle (1500 head each). We begin by simulating per head weekly revenue (grid and dressed weight) for each animal and the revenue differential for each animal (grid minus dressed weight). In the next step, weekly pen level average per head revenue and the per head revenue differential are derived. As a result, two data sets are created containing weekly pen level averages for per head revenue and the per head revenue differential for a 381 week period.

The two pens differ with respect to carcass quality but individual animal carcass attributes remained fixed over the timeframe of the study. We employ an EARCH-in-Mean regression modeling procedure to analyze the variation in the average per head revenue differential for the two pens. The EARCH model is uniquely suited for analyzing the empirical issues associated with marketing risk addressed in this study. The EARCH term (Nelson 1991) allows for producers' asymmetric response to good vs. bad news. The "Mean term" (Engle, Lilien and Robins 1987) provides an empirical estimator to test for the possibility of a risk premium associated with volatility.

Our empirical results indicate that the incentive to market high (low) quality cattle on a grid (by the pen) has increased (decreased) during the timeframe covered in this study. This finding indicates that the grid pricing system's role as a value based pricing system is strengthening over time. Furthermore, we incorporated the model's conditional variance as an explanatory variable and found that *market risk* does affect the incentive structure associated with the decision to market on a grid or by the pen. The incorporation of price volatility modeling tools into the grid pricing literature reflects a contribution to the empirical literature on marketing behavior in U.S. livestock markets.

Literature Review

Agricultural economists have investigated a number of issues pertaining to the beef industry's value based marketing (VBM) initiative for slaughter cattle. A general discussion of this literature can be found in Fausti et al. (2010a). The success of the value based marketing initiative cannot be measured by a single metric. Consumer acceptance can be measured by changes in beef demand over time (Schroeder et al. 2000), or investigated using experimental methods (e.g., Umberger 2007). Production efficiency, with respect to carcass quality, has been investigated in the context of technological innovation to enhance value based beef production and marketing methods (e.g., Lusk 2007; Koontz et al. 2008).

A white paper (*War on Fat*) published by the Value Based Marketing Task Force (VBMTF 1990) specifically discussed the need for an alternative pricing system to the traditional practice of selling fed cattle at an average price by the pen. Selling fed cattle at an average price by the pen is viewed by the beef industry (VBMTF: consensus point 7) as an inefficient pricing mechanism because it distorts market signals from the consumer to the producer (Feuz et al. 1993) with respect to carcass quality. The price signal issue arises because selling slaughter cattle by the pen at a negotiated price per hundred weight allows pricing error to enter into the transaction because carcass quality: a) is unknown at the time of the transaction, and b) is not uniform across all animals in a pen. Thus, animals with desirable carcass attributes are paid the same price per pound as animals with undesirable carcass attributes. Thus, low quality cattle are paid a premium above their actual market value, and high quality cattle are penalized by being paid a price per pound below their actual market value. The implication is that producers who sell by the pen do not receive a price signal on carcass quality differences for the animals within a pen.

The introduction of grid pricing mechanisms (GPM) as a value-based pricing system alternative to pen level sales reflects the beef industry's desire to improve carcass quality through the market mechanism (Fausti et al. 1998). Grid pricing mechanisms have been touted by the beef industry and academic researchers as a key component in the development of a value based marketing system for fed cattle (Schroeder et al. 1998). The goal of a grid pricing system is to provide a mechanism that rewards desirable carcass attributes and discounts undesirable carcass attributes, thus providing a market signal that will encourage producers to improve carcass quality.

Agricultural economists have investigated the effectiveness of GPM as a price transmission mechanism from consumers to producers (e.g., McDonald and Schroeder 2003; Johnson and Ward 2005 & 2006). The general consensus is that carcass weight rather than grid premiums and discounts assigned to carcass quality attributes is still a very important component of the GPM price signal. Johnson and Ward (2006) report that for cattle with the highest (lowest) carcass quality sold on a grid, weight accounted for 79% (50%) of the market signal. Furthermore, they report that grid discounts account for 20% and 49.5% of the market signal for high quality and the low quality cattle groups in their study, respectively. Their findings are consistent with earlier studies that have raised the issue that the GPM premium and discount structure may act as a "barrier to adoption" of grid pricing by producers (e.g., Fausti and Qasmi 2002).

The goal of the VBM initiative is to transform the beef industry's production and marketing system along the entire supply chain. To accomplish this goal, a VBM pricing system needs to capture a dominant share of fed cattle sales. While grid marketing has increased in importance as a pricing method for fed cattle over the last fifteen years, it has not replaced average pricing by the pen as the dominant marketing option selected by fed cattle producers. Fausti et al. (2010a) provides empirical estimates that grid market share of steer and heifer slaughter has increased from the low teens in the 1990s to approximately 45% in 2009. The inability of the grid pricing system to capture a dominant share of fed cattle slaughter implies a weakness in the incentive mechanism.

Conceptually, an important objective of GPM as an integral component of a value based marketing system is to induce fed cattle producers to sell their cattle on a grid. The benefits to producers who sell on a grid touted by the beef industry are: a) producers will be rewarded for the above average cattle they sell on a grid, and b) producers will be given detailed information on the quality of each individual carcass by the packer. Carcass information and the premiums represent the grid market signal to the producer that is absent when cattle are sold at an average price by the pen. In turn, the producer will make adjustments to the production system to improve the carcass quality of animals sold in the future. However, there is also risk the producer must accept. When a producer sells on a grid the producer faces uncertainty concerning the average quality of animals being sold. This uncertainty creates a financial risk because the cattle may be of lower quality than the producer expected. The reason why this financial risk exists is because all producers have the option of selling cattle by the pen at an average price. In this case, the buyer (packer) assumes the financial risk associated with carcass quality uncertainty.

Numerous studies have identified financial risk factors affecting the behavior of buyer and sellers in the fed cattle market (e.g., Feuz et al. 1995; Anderson and Zeuli 2001; White et al. 2007; Belasco et al. 2010; Fausti et al. 2013). The Theory of Factor Price Disparity formally addresses the financial risk issue associated with carcass quality uncertainty (Fausti and Feuz 1995). Fausti and Feuz (1995) identified the economic consequences of carcass quality uncertainty on buyer pricing decisions and seller marketing decisions. They demonstrate that packer's will charge a risk premium when purchasing cattle by the pen due to carcass quality uncertainty. They also hypothesize that seller risk preference combined with carcass quality uncertainty provides a reasonable explanation for the coexistence for multiple marketing alternatives for slaughter cattle. In a recently published article, Fausti et al. (2012) demonstrate that risk preference in conjunction with carcass quality uncertainty does contribute to the existence of multiple marketing methods for slaughter cattle.

The key to accomplishing the beef industry's goal of having a dominant value based pricing system is dependent on how effective the grid pricing system's incentive mechanism is at transmitting market signals to producers. A key indicator of success would be if the incentive to market higher quality cattle on a grid strengthens over time and the disincentive to market lower quality cattle on a grid weakens over time. A weakening of the incentive to market lower quality cattle by the pen at an average price relative to selling on a grid will encourage producers to increase their use of a grid when marketing fed cattle. In turn, information of grid performance will encourage producers to adopt value based production practices. According to Fausti et al. (1998), a key metric of success for the beef industry's value based initiative is a reduction in the "barriers to adoption" of its value based pricing system.

Thus, a logical approach for evaluating the effectiveness of the GPM incentive mechanism is to compare its performance as a signaling mechanism relative to the alternative pricing methods available to producers. Evaluating market outcomes for cattle sold on a grid relative to cattle sold on a live or dressed weight has been a common practice in the grid pricing literature (e.g., Fausti et al. 1998; Schroeder and Graff 2000; Anderson and Zeuli 2001). Fausti and Feuz (1995) and Feuz et al. (1995) suggest that the price differential between grid and average pricing reflects the risk premium buyers (sellers) are willing to pay to accept (avoid) the financial risk associated with carcass quality uncertainty. The empirical analysis to follow assumes the revenue differential reflects the risk premium associated with carcass quality uncertainty. Thus, the empirically estimated weekly revenue differential represents the weekly market risk premium associated with carcass quality uncertainty.

Data

Carcass data on 2590 slaughter steers was collected from a retained ownership study conducted by South Dakota State University. A random sampling procedure was employed to construct two data sets. The first dataset, labeled "Choice" data, consists of 2/3 choice grade steers and 1/3 select grade steers, whereas the second dataset "Select" includes 2/3 select grade steers and 1/3 choice grade steers.[1] Table 1 contains the summary statistics for the two data sets.

Table 1. Summary Statistics: Cattle Carcass Attributes

Data Set/ Variable	N	Mean	Std. Dev.	Minimum	Maximum
Select Data Set:					
HCW	1500	718.57	74.61	478.00	964.00
QG	1500	2.70	0.53	1.00	4.00
YG	1500	2.66	0.64	0.64	5.06
Choice Data Set:					
HCW	1500	719.37	73.84	478.00	964.00
QG	1500	2.35	0.52	1.00	4.00
YG	1500	2.78	0.62	0.64	5.06

The carcass data were used to simulate weekly per-head market values using both a grid pricing system and the hot weight carcass (HCW) pricing system. Summary statistics for the weekly market simulation data were derived. Included in the summary statistics were the weekly statistical mean (n=1500) and standard deviation for: a) per-head grid and HCW revenues, b) the grid minus HCW differential using a "matched pairs" process, c) the standard deviation for grid revenue and HCW revenue, and d) the weekly grid revenue standard deviation minus the HCW standard deviation. The summary statistics data were collected for each week in the study and used to construct the 381 week data set (April 2001 to July 2008).[2] The weekly matched pair price differential, ${}_{i=1}^{1500}(GridREV_i - HCWREV_i)\ /1500$, is the variable of interest and is denoted as $RevD_t$ for the high and low quality grade pens. Summary statistics describing the data can be found in Tables 2 and 3.

Table 2. Summary Statistics: National Carcass Premiums and Discounts for Slaughter Steers and Heifers ($ per hundred weight)

Variable	N	Mean	Std. Dev.	Minimum	Maximum
Choice/Select	381	-9.81	4.44	-24.87	-2.84
YG 1-2	381	2.88	0.29	1.89	4.30
YG>5	381	-18.47	0.73	-22.71	-16.55

Weekly grid price per-head was determined using a calculated weekly base price and the weekly AMS additive grid as proposed by Fausti et al. (1998). Weekly grid premium and discount data were collected from USDA-AMS weekly report (LM_CT155): *National Carcass Premiums and Discounts for Slaughter Steers and Heifers*. The pen level HCW weekly price data were collected from the Nebraska Weekly Direct Slaughter Cattle-Negotiated Purchases report (LM_CT158). The reported HCW price selected is for dressed delivered steers grading 35% to 65% choice.

Table 3. Summary Statistics

Variable	Obs.	Mean	Std. Dev.	Minimum	Maximum
Select Data Set:					
GRIDREV	381	939.54	115.22	698.71	1240.62
SDGRIDRE	381	106.65	13.58	79.56	155.48
HCWREV	381	944.87	114.91	702.75	1253.61
SDHCW	381	98.11	11.93	72.97	130.16
DIFFREV*	381	-5.33	3.66	-18.54	3.20
DIFFSD*	381	8.54	5.12	3.30	48.40
Choice Data Set:					
GRIDREV	381	963.31	118.12	714.40	1291.02
SDGRIDRE	381	108.94	14.07	81.11	153.94
HCWREV	381	945.71	114.57	703.54	1192.50
SDHCW	381	97.11	11.82	72.21	128.81
DIFFREV*	381	17.27	8.37	-3.64	42.36
DIFFSD*	381	11.83	6.01	3.02	36.84

"*" denotes statistically significant at the 1% level.

Explanatory variables were selected based on potential influence on $RevD_t$. Given that carcass quality is being held constant over time, reported weekly AMS grid premiums and discounts, a seasonality dummy variable, and a time trend variable were selected as explanatory variables. Since grid premiums and discounts within the quality and yield grade categories are highly correlated, we selected the choice/select discount, yield grade 1-2 premium, and the yield grade 5 discount as proxies for the grid pricing system in our empirical model. We converted the grid discounts to positive values by reversing the sign to simplify interpretation.

Methodology

We employ an EARCH-in-Mean regression model to analyze revenue differential variability for the choice and select datasets. The revenue differential is defined as the pen average of the per-head matched pair revenue difference between the AMS grid and the HCW pricing alternative. Following the price discovery literature (Ward 1987, Feuz et al., 1995, Fausti and Feuz, 1995), we consider informational disparity over cattle quality and the associated financial risk as primary factors explaining the revenue differentials (market risk premium) between the two marketing alternatives. The general economic relationship is defined as $RevD_t$ = f(grid premiums, grid discounts, carcass quality risk).

Other important factors are also included, such as past revenue differentials, the potential trend in preference for the AMS grid marketing alternative and seasonal price patterns. We propose the following regression for the revenue differential for the two data sets:

$$RevD_t = const + \sum_{i=1}^{L} \emptyset_i RevD_{t-i} + \beta_1 selectp_t + \beta_2 yg2_t + \beta_3 yg5p_t + \beta_4 T_t + \beta_5 DS_t + \delta ln\ h_t + \varepsilon_t, \quad (1)$$

where $RevD_t$, $const$, $RevD_{t-i}$, $selectp_t$, $yg2_t$, $yg5p_t$, T_t, DS_t and h_t are the weekly revenue differential, intercept, lagged revenue differential, the choice-select premium, the yield grade 1-2 premium, the yield grade 5 discount, time trend, seasonal dummy and conditional variance (risk) associated with the regression residual ε_t[3], respectively. In particular, $selectp_t$, $yg2_t$ and $yg5p_t$ capture the informational disparity over quality; the logarithm of h_t is considered as a proxy for risk.

Dickey-Fuller unit root tests confirmed stationary of all relevant variables used in the regression models. Durbin-Watson test statistics based on preliminary regression analysis indicate the error terms ε_t are auto-correlated. The Q and LM test statistics show that a significant ARCH effect is present in the residuals of the regression. The following EARCH (p,q) model is employed to account for the above effects.

$$\varepsilon_t + \sum_{n=1}^{N} \rho_n \varepsilon_{t-n} = \sqrt{h_t} e_t \qquad (2)$$

$$ln(h_t) = \omega + \sum_{i=1}^{q} \alpha_i [\theta e_{t-i} + (|e_{t-i}| - E|e_{t-i}|)] \qquad (3)$$

where $e_t \sim i.i.d.N(0,1)$.

Additionally, the EARCH model has two desirable features that are not available in the traditional (G)ARCH model. First, the parameters in (3) are not restricted to be positive. Second, the item in the bracket, denoted as $g(e_{t-i}) = \theta e_{t-i} + (|e_{t-i}| - E|e_{t-i}|)$, can capture the asymmetric effects of residual shocks on the conditional variance. Asymmetry exists when the coefficient of e_{t-i} is $\theta + 1$ for "good news" $e_{t-i} > 0$ and $\theta - 1$ for "bad news" $e_{t-i} < 0$. In particular, θ and the term $|e_{t-i}| - E|e_{t-i}|$ are often referred to as the sign effect and the size effect, respectively.

Lastly, we determine the appropriate order of lags in Equations (1) through (3). For the regression model (Equation 1), we choose L=3 lags of $RevD_t$ for the choice dataset and 4 lags for the select dataset based on the 5% significance level. For the model of auto-correlated errors (Equation 2), we first assume constant h_t and then run the regression model with auto-correlated errors. We remove insignificant lags from a maximum length of 13 (approximately equal to one quarter) based on backward elimination. More specifically, we retain the first four lags for the choice dataset and the third and fourth orders for the select dataset. For the EARCH model (Equation 3), we employ the minimum number of lags while ensuring the normality of the residual e_t. It amounts to the choice of q=9 for the choice dataset and q=5 for the select dataset.[4]

Using the above settings, we verify the suitability of the EGARCH-in-Mean regression model, reported in Table 4. The respective model fits the choice dataset better than the select dataset based on standard regression error measures (SSE, MSE, MAE , MAPE, and R^2). The p-values of the Jacque-Berra normality test are 0.70 and 0.75 for the choice and select datasets, respectively. We cannot reject the null hypothesis of normality of residual e_t, which confirms the critical normality assumption of the EARCH model.

Table 4. Model Diagnostics

	Choice	Select
OBS	378.00	377.00
LogLik	-502.93	-551.46
SSE	409.80	613.03
MSE	1.08	1.63
MAE	0.75	0.88
MAPE	4.76	43.13
R-Sq.	0.98	0.88
SBC	1166.10	1233.43
AIC	1059.86	1146.92
AICC	1064.18	1149.78
J-B Test	0.72	0.57
Pr > χ^2	0.70	0.75

Empirical Results

The summary statistics presented in Table 3 are consistent with the empirical literature on grid pricing. Summary statistics reflect long-run marketing outcomes for two pens of cattle holding carcass quality attributes constant over time. Empirical evidence indicates that higher quality cattle are rewarded on a grid and lower quality cattle are penalized relative to selling at an average price. Regardless of cattle carcass quality, revenue variability is higher when marketing on a grid.

The summary statistics also provide insight on the relationship between financial risk and carcass quality uncertainty. Assume the producer is uncertain about the carcass quality of his/her cattle and the producer owns both the choice and select pens. Summary statistics provided in Table 3 show that for these two sets of cattle there is an average per-head revenue differential of $23.77 when marketing above average cattle on a grid relative to selling below average cattle on a grid ($963.31-939.54). If the producer is uncertain about the carcass quality of the cattle he/she is selling, then this revenue differential represents the per-head financial risk the producer faces. On the other hand, comparing revenue from selling below and above average cattle at an average HCW price resulted in only an 84 cent HCWP per-head differential between pens. In this case, the financial risk the producer faces is almost zero. This non-zero differential is the result of the minimal weight difference across pens. These findings are consistent with Anderson and Zeuli (2001: p. 284) who concluded that: “Errors in the seller’s judgment of a pen of cattle’s quality can have a significant impact on grid pricing returns, while having little or no impact on returns to live pricing.”

The EARCH-in-Mean regression model is estimated using maximum likelihood. The results for the choice and select datasets are reported in the left and right panels of Table 5, respectively. We analyze the regression results before presenting the EARCH model. All results are compared between the two datasets.

Table 5. EARCH-in-Mean Regression Results

	Choice				Select			
Variable	Estimate	Std. Error.	t-value	prob.	Estimate	Std. Error.	t-value	prob.
Constant	1.880	2.173	0.87	0.3868	4.911	1.703	2.88	0.0039
$RevD_{t-1}$	0.0619	0.030	2.05	0.0406	0.460	0.040	11.39	<.0001
$RevD_{t-2}$	-0.0790	0.028	-2.83	0.0046	0.019	0.035	0.53	0.5934
$RevD_{t-3}$	0.0539	0.027	2.04	0.0418	-0.278	0.036	-7.82	<.0001
$RevD_{t-4}$	-	-	-	-	0.080	0.028	2.92	0.0035
selectp	1.562	0.044	35.60	<.0001	-0.485	0.022	-22.13	<.0001
yg2	1.770	0.251	7.06	<.0001	3.013	0.222	13.56	<.0001
yg5p	-0.590	0.087	-6.83	<.0001	-0.992	0.078	-12.77	<.0001
T	0.012	0.003	4.00	<.0001	0.013	0.001	9.60	<.0001
DS1	0.377	0.192	1.97	0.0492	0.036	0.127	0.29	0.7740
DS2	0.763	0.352	2.17	0.0303	0.617	0.184	3.34	0.0008
DS3	0.612	0.321	1.91	0.0565	0.377	0.170	2.22	0.0263
AR1(ρ_1)	-0.633	0.063	-10.00	<.0001	-	-	-	-
AR2(ρ_2)	-0.242	0.071	-3.39	0.0007	-	-	-	-
AR3(ρ_3)	0.040	0.070	0.57	0.5656	-0.504	0.035	-14.33	<.0001
AR4(ρ_4)	-0.079	0.051	-1.55	0.1211	-0.306	0.032	-9.54	<.0001
EARCH0(ω)	-0.152	0.179	-0.85	0.3965	0.137	0.203	0.68	0.4985
EARCH1(α_1)	0.478	0.137	3.49	0.0005	1.160	0.111	10.45	<.0001
EARCH2(α_2)	0.626	0.129	4.86	<.0001	0.622	0.123	5.05	<.0001
EARCH3(α_3)	0.786	0.137	5.72	<.0001	0.935	0.136	6.89	<.0001
EARCH4(α_4)	0.263	0.139	1.89	0.0591	0.777	0.120	6.47	<.0001
EARCH5(α_5)	-0.062	0.146	-0.42	0.6741	0.227	0.108	2.11	0.0350
EARCH6(α_6)	0.013	0.134	0.09	0.9259	-	-	-	-
EARCH7(α_7)	0.085	0.125	0.68	0.4960	-	-	-	-
EARCH8(α_8)	-0.120	0.137	-0.87	0.3820	-	-	-	-
EARCH8(α_9)	0.469	0.118	3.98	<.0001	-	-	-	-
θ	-0.193	0.076	-2.53	0.0113	-0.133	0.060	-2.22	0.0267
δ	-0.120	0.066	-1.79	0.0728	-0.158	0.038	-4.18	<.0001

Regression Results: Grid Premiums and Discounts

In Table 5, the estimated coefficient for the choice-select discount $selectp_t$ is $1.56 for the choice dataset vs. -$0.49 for the select dataset. The choice-select discount essentially functions as a market signal on the current revenue differential between carcasses with a higher percentage in the level of intramuscular fat and carcasses with a lower percentage. The grid pricing literature has documented that the quality grade price differential is the dominant carcass characteristic explaining per-head revenue variability (e.g., Johnson and Ward 2005 & 2006). The empirical estimates for $selectp_t$ indicates that for a one dollar increase in the choice premium (select discount) will; a) increase the per-head revenue differential (the incentive to market on a grid) for the choice pen by $1.56, and b) lower the per-head revenue differential (the disincentive to market on a grid) for the select pen by $0.49. Our empirical estimates clearly indicate that change in the choice/select spread alters the financial risk producers' face when deciding to sell cattle on a grid or market by the pen.

Empirical estimates for the yield grade premium and discount variables indicate that they affect the per head revenue differential ($RevD_t$) for the choice and select pens. The premium "*yg2*" for high yielding (boneless retail cuts) carcasses has a positive relationship with the per head revenue differential for both the choice and select pens. As in the case of the choice/select spread, our empirical estimates indicate that a change in "*yg2*" premium affects the incentive (disincentive) to sell cattle on a grid (by the pen). For the select pen, a one dollar increase in the "*yg2*" premium will decrease the per-head revenue differential discount (based on -$5.33 statistical mean for the per head revenue differential) by $3.01 to -$2.32. Thus a one dollar increase in the "*yg2*" premium reduces the incentive to market the select pen at an average price. On the other hand, for the choice pen, the incentive to market on a grid increases by $1.77.

These empirical estimates suggest, ceteris paribus, a $1 increase in the *yg2* premium increases the producer's incentive to market on a grid regardless of carcass quality expectations.

The final grid price variable included in the model is yield grade 5 (*yg5p)* and the coefficients are negative in both the choice and the select models. A one dollar increase in the "*yg5p*" discount will reduce the incentive to sell the choice pen on a grid by $0.59 and for the select pen, the incentive to market by the pen increases by $0.99. This implies, ceteris paribus, a $1 increase in the *yg5p* premium reduces the producer's incentive to market on a grid regardless of carcass quality expectations.

One interesting implication from our analysis above suggests that a simultaneous increase in the choice-select discount and the yield grade 1-2 premium will send conflicting market signals to producers of lower quality grade cattle but a positive market signal to producers of higher quality grade cattle. This inherent conflict in the structure of the grid pricing system appears to be a "barrier to adoption" that has not been identified in the previous literature.

Regression Results: Time Trend and Seasonality

The literature has yet to answer the question: is the incentive structure of the grid pricing system evolving over time? The estimated time trend regression coefficients can help address this question. From Table 5, we find that *T* is positive and statistically significant in both models. This implies that during the sample period (2001-2008) the revenue differential for both the choice and select datasets exhibited a positive trend. This suggests that the incentive to market high and low quality cattle on the grid has strengthened over time.

In a recent article by Fausti et al. (2010a), it is reported that grid market share of steer and heifer slaughter volume increased from 35.8% in 2004 to 38.8% in 2008. The increase in grid market share of slaughter volume is consistent with our empirical finding that the incentive mechanism for marketing on the grid has strengthened and the incentive to market by the pen has declined during the period covered in the data. Documentation of the evolving nature of the grid pricing system's incentive mechanism provides opportunities for additional research on this issue.

Peel and Meyer (2002) discuss the seasonal pattern in fed cattle prices; price is lower in the summer and higher otherwise. The revenue differential doesn't follow the same seasonal pattern and has been discussed in the grid pricing literature. In our model, the quarterly seasonal dummy variables (DS_i : i=1 to 3) is defined as 0 for the January through March quarter, one otherwise. For the select dataset the third and fourth quarter coefficients are positive and significant at the 5% level. All three seasonal dummy coefficients are positive and significant at the 10% level for the choice dataset. Our seasonality estimates indicate that the incentive to market high quality cattle in the spring, summer and fall strengthens. However, for the select dataset, the positive coefficients indicate the incentive to market below average cattle by the pen is reduced in the 3rd and 4rd quarters. Therefore, the revenue differential does exhibit seasonality and the estimates suggest the seasonal effects are stronger for high quality cattle. Our results appear to be consistent with previous seasonal patterns reported in the literature (e.g., Fausti and Qasmi 2002). Fausti and Qasmi find that if producers are uncertain about the quality of cattle they are selling, the revenue differential between high and low quality cattle narrows in the winter and spring quarters and widens in the summer and fall quarters. In contrast, we find that seasonal effect is actually a positive shift in the incentive structure favoring the marketing option of selling on a grid during the summer and fall.

EARCH-in-Mean Model Results and Implications for Marketing Risk

The EARCH-in-Mean model can be decomposed into five effects: the sign effect θe_t , the size effect[5] $|e_t| - E|e_t|$, the ARCH effect α , and risk premium $\delta ln(h_t)$. The sign (or asymmetry) effect is statistically significant and negative for both datasets. A non-zero θ indicates asymmetric response of conditional variance to past shocks. The majority of the ARCH coefficients are positive for both datasets, implying that the past negative (positive) shocks are associated with higher (lower) conditional variance h_t given a negative θ.[6]

To visualize the asymmetry, the item that combines the sign and size effects $g(e_{t-i}) = \theta e_{t-i} + (|e_{t-i}| - E|e_{t-i}|)$ is plotted as a function of the shock e_{t-1} for the choice and select datasets in Figure 1. The conditional variance (logarithm) of the residuals (conditional on the information up to period t-1: H_{t-1}) for the choice and select datasets increases more in response to negative shocks to the revenue differential ($\theta - 1$) than to positive shocks ($\theta + 1$). The inference is that the volatility associated with the revenue differential is more sensitive to negative shocks than positive shocks, as shown in the first quadrant of Figure 1. This implies the financial consequence of increased uncertainty associated with the revenue differential is higher for negative shocks relative to positive shocks (first vs. second quadrant).

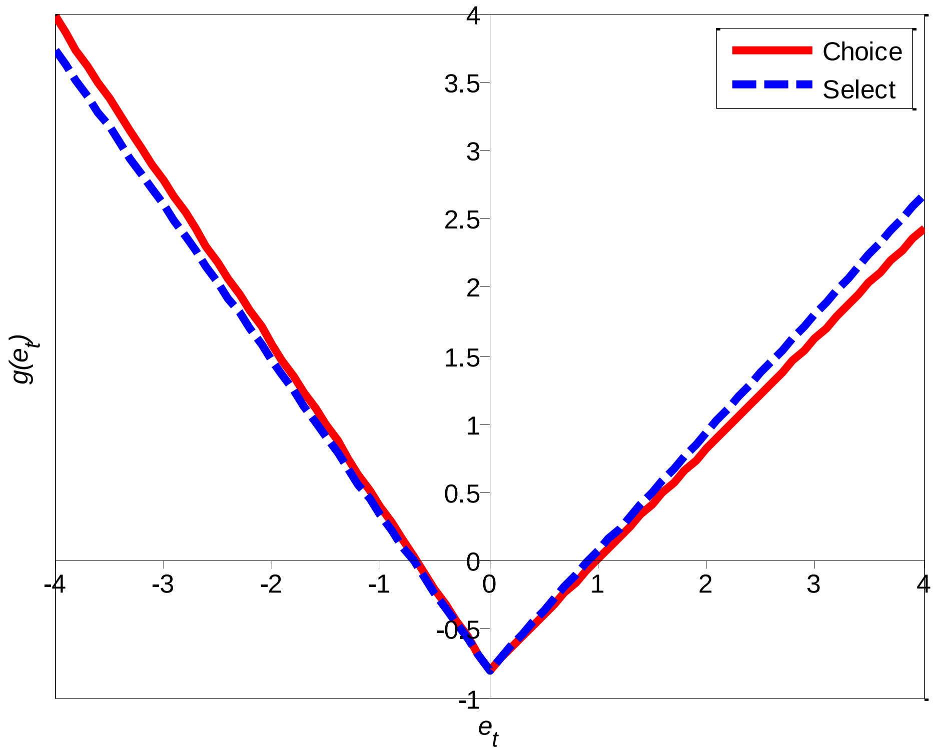
For any particular week, the per-head revenue differential represents the market risk premium, positive for above average quality cattle and negative for below average quality cattle. The producer's marketing decision to sell by the pen or on the grid will be determined by a comparison of the individual seller's risk premium as determined by his/her risk preferences relative to the market risk premium (see Fausti et al. 2012). If there is greater uncertainty surrounding the market risk premium (holding its expected value constant), then risk averse sellers will increase their required risk premium to sell on a grid. Thus, ceteris paribus, there will be a subgroup of sellers who will shift from marketing on a grid to marketing by the pen (Fausti et al. 2012). Empirical evidence indicates both positive and negative shocks to the revenue differential will increase the level of uncertainty associated with the market risk premium.

On a final note, our discussion of the asymmetric effect of shocks on the conditional variance implies that the level of uncertainty associated with the market risk premium is dependent on cattle quality (Figure 1). For the select (choice) dataset uncertainty associated with the market risk premium is more sensitive to positive (negative) shocks relative to the choice (select) dataset. We conclude that shocks to the market risk premium will alter risk-averse producers' marketing decisions in a manner consistent with Fausti et al. (2012):

a) A positive price shock will increase the incentive to market on a grid [e.g., if $\Delta e_t > 0$ then $\Delta GridRev_t - \Delta HCWRev_t > 0$]. A negative shock will increase the disincentive to market on a grid. These results hold regardless of cattle quality.
b) For above average cattle, a positive shock increases the incentive to market on the grid but it also increases the risk. In this case, the effect of the shock is dependent upon the producer's risk preferences. A risk neutral producer will view the positive shock as an increase in the incentive to market on a grid. A risk-averse producer's view will be dependent upon their degree of risk aversion. On the other hand, a negative shock results in an increase in the disincentive to market on the grid but also increases the risk. In this case, the dual effects of a negative price shock are reinforcing. This implies that both risk- neutral and risk-averse producers will view a negative price shock as a weakening of the incentive to market on a grid.
c) For below average cattle, a positive shock reduces the disincentive to market on the grid but increases risk so the effect on a producer's marketing decision is dependent on risk

preferences. For a negative shock, the disincentive to market on the grid increases and the risk increases. In this case, risk-neutral and risk-averse producers will view a negative price shock as strengthening the disincentive to market on a grid.

Figure 1. Asymmetric Effects of Shocks on Risks



The last issue to be addressed is the effect of a change in the conditional variance on the market risk premium. Engle, Lilien, and Robins (1987) introduced the ARCH-in-M model, which allows the conditional variance to affect the mean, to show that a risk-averse investor will demand a risk premium to hold long term bonds relative to short term bonds. In our model, we take the logarithm of conditional variance because it is the only functional form that ensures the normality of the ARCH residual.[7] The volatility effect on the market risk premium is captured by (δ), which is statistically significant and negative for both datasets. A simple description of δ

is that it represents the component of the market risk premium due to the uncertainty. A proxy for this uncertainty would be the standard deviations associated with mean values reported for DiffRev in Table 3 for the choice and select datasets. If we assume that the conditional variance is a proxy for the risk, the risk premium (δ) associated with logarithm of h_t is statistically significant and negative for the select and choice datasets. We interpret this result as an indication that sellers of fed cattle are more willing to market their cattle by the pen in order to avoid an even larger penalty on the grid when there is greater uncertainty surrounding the market risk premium. The EARCH model confirms the view in the literature that carcass quality uncertainty injects financial risk into the marketing decision. Thus, increased producer uncertainty over the market risk premium renders their decision to sell cattle on a grid to be inherently risker.

Summary

There are three pricing alternatives that producers have to select from when marketing their fed cattle (live weight, dressed weight, and grid). The coexistence of pen level pricing systems with the individual animal grid pricing system is an obstacle in the path of the beef industry's goal of transforming itself into a value based production and marketing system. Selling cattle at an average price by the pen is still very appealing to producers, who are risk-averse, or lack the financial capital to adopt value based production technology, or lack economies of scale to gain access to marketing outlets that offer a grid pricing alternative (see Fausti et al. 2010 for additional discussion on these issues). However, changes in the grid incentive structure can mitigate these barriers. The empirical evidence suggests that changes in yield grade premiums are more effective in shifting the incentive structure in the direction that is more favorable for marketing on a grid than changes in the select/choice discount for below average quality grade cattle.

The empirical evidence clearly shows how the financial risk of carcass quality uncertainty is injected into producer marketing decisions with respect to selling on a grid versus selling by the pen at an average price. An equally important contribution to the literature is the analysis of how producers react to shocks to the grid incentive mechanism. Evidence suggests that negative shocks reduce the incentive to market on a grid and increase the incentive to market by the pen at an average price. Thus, the financial risk associated with shocks will continue to affect producer marketing decisions and remain a barrier to adoption. However, the adoption of VBM production and marketing technology does offer producers a tool to mitigate their exposure to this type of financial risk.

Finally, empirical results suggest that the grid premium and discount structure is slowly adjusting in a manner that encourages marketing on a grid and discourages marketing by the pen at an average price. If this trend continues, grid market share of steer and heifer slaughter volume should increase in the future.

Footnotes

[1] Additional information on these data sets can be found in Fausti et al. (1998).

[2] We did not include AMS grid premium and discount data from October 1996 to April 2001 (pre mandatory livestock price reporting period) due a recent study by Fausti et al. (2010b). This study suggests that AMS publicly reported weekly grid premium and discount data may have been influenced by sample selection bias.

[3]Conditional variance h_t is defined precisely by the EARCH model in Equations (2) and (3). The conditional variance reflects volatility in the per-head revenue differential i.e., the price incentive to market on a grid. The conditional variance is the proxy for financial risk associated with that incentive.

[4]We also estimated the same model with an added EGARCH term. We find that the GARCH term is not statistically significant regardless of lag length. Therefore, we choose the EARCH-in-Mean model, instead of EGARCH-in-Mean modeling procedure.

[5] Here we fix the magnitude of the size effect to be “1”, instead of a multiplication of $(|e_t| - E|e_t|)$ for simplicity.

[6] The expectation of the ARCH term is $\alpha * E[g(e_t)] = \alpha * \theta * E(e_t | e_t > 0)$. For example, if $\alpha > 0$ a negative θ will result in negative value of the ARCH term when $e_t > 0$. The opposite holds when $e_t < 0$.

[7] Two other forms were examined, the linear form as in Engle, Lilien and Robins (1987) and the square-root form. Neither produces an ARCH residual that passes the normality test. In fact, Engle, Lilien and Robins (1987) find that the log-linear form is preferred to the linear form in their empirical test.

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