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Models Estimating Beef Quality and Yield Grade Discounts

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Grid pricing of fed cattle, from a pricing accuracy standpoint, is arguably superior to either live weight or dressed (carcass) weight pricing (Feuz; Ward and Lee; Schroeder, and Graff). Grid pricing could be called carcass merit (and demerit) pricing. The incentive and disincentive mechanism embodied in a grid pricing system is a function of the grid's premium and discount structure. However, the incentive structure has been criticized as an obstacle preventing many slaughter cattle producers from selecting grid pricing (Fausti and Qasmi).

In a grid pricing scheme, each animal is priced separately based on that animal's own carcass characteristics. Grids typically have premiums and discounts associated with USDA quality and yield grades, carcass weights, and less- or non-merchantable carcasses. Historically, Prime quality grade carcasses receive a price premium which has been fairly constant over time (Ward, Feuz, and Schroeder). Choice is the benchmark grade. The Choice-Select discount (i.e., price difference) is a focal point for grid pricing and has been rather volatile over time. The Select-Standard discount is nearly a linear combination of the Choice-Select discount.

For yield grades, yield grade 1 and 2 carcasses historically receive a price premium which has remained relatively stable over time (Ward, Feuz, and Schroeder). Yield grade 3 is the benchmark. The yield grade3-yield grade 4-5 discount is the focal point for yield grade discounts and has been the most volatile over time. Yield grade 5 appears to be a linear combination of the yield grade 4-5 discount.

These two carcass discounts (i.e., Choice-Select and yield grade 3-yield grade 4-5) are clearly very important to the net grid price as noted and confirmed in several studies (Feuz; Ward and Lee; Schroeder, and Graff; Anderson and Zeuli; Fausti and Qasmi; Whitley; McDonald and Schroeder). However, little research as attempted to explain the behavior of the two carcass discount series. Preliminary work (LMIC) identifies data available for estimating a weekly carcass discount model, reports one model estimation, and asserts that more research is needed.

This paper reports an attempt to determine economic factors that influence the Choice-Select and yield grade 4-5 price discounts. Understanding the discounts and variables affecting them is important to producers and packers involved in grid pricing of fed cattle.

Conceptual Framework and Hypotheses

Premiums and discounts related to quality grades have their origin in consumer demand since quality grades are intended to relate to eating quality and consumer satisfaction. Yield grades do not relate to consumer satisfaction directly but to the amount of marketable retail cuts from the carcass. Thus, yield grade price differences originate from value differences in inputs.

A cursory analysis of the historical carcass discount series suggests some hypotheses.

- First, seasonality exists in both series.
- Second, through carcass weight, the two series move in somewhat of a mirror pattern. As quality grade of an animal or pen goes from Standard toward Prime it is probable that yield grade is simultaneously increasing from yield grade 1 to 5 (i.e., meaning lower yielding carcasses). Concurrently, the two discount series also move inversely. For example, as carcass weights increase, the percentage of Choice grade carcasses typically increases, leading to a narrowing of the Choice-Select price spread. However, heavier carcasses simultaneously mean higher yield grades typically, leading to a widening of the yield grade 4-5 price spread.
- Third, it appears mandatory price reporting (MPR) affected the carcass discount series. The two carcass discount series were from USDAs "National Carcass Premiums and Discounts For Slaughter Steers and Heifers" report and obtained from Livestock Marketing Information Center. The weekly data series used began February 17, 1997 and ended March 17, 2003, thus encompassing the introduction of MPR, April 3, 2001. Visual inspection of the data suggests differences in variability pre-MPR vs. post-MPR.

Analysis and Model Specification

Student's-t and F-tests were used to determine if the Choice-Select and yield grade 4-5 series have the same means and variances respectively before and after MPR. These statistical tests were conducted with Simetar© (Richardson). Tests confirmed that the pre-MPR Choice-Select discount mean was not significantly different than the post-

MPR mean but the variances were significantly different (Table 1). The variance prior to implementation of MPR was larger than the variance afterwards. For the yield grade 4-5 discount series, tests confirmed that both the pre-MPR mean and variance were significantly different than the post-MPR mean and variance. The post-MPR mean was lower and the variance also was less.

Several alternative specifications of models were considered and each was evaluated based on a series of statistical tests. One specification was derived from demand theory but was discarded due to numerous econometric problems. Others were based on a *priori* expectations of those characteristics that influence the Choice – Select discount, e.g., as in this general specification of a Choice-Select model

$$P_{ch-sel} = f(q_{\%choice}, q_{\%YG4-5}, P_{BoxedBeef}, q_{Production}, \delta_s), \quad (1)$$

where $P_{ch\text{-}sel}$ is the Choice – Select discount, $q_{\%choice}$ is the percentage of Choice beef in the period's production, $q_{\%YG4\text{-}5}$ is the percentage of yield grade 4-5 in the period's production, $P_{BoxedBeef}$ is the price of wholesale boxed beef, $q_{Production}$ is the quantity of production for this period, and δ_s is a seasonal component. Similarly, a general specification of a yield grade 4-5 discount model could be

$$P_{YG4-5} = f(q_{\%choice}, q_{\%YG4-5}, P_{BoxedBeef}, q_{Production}, \delta_s), \quad (2)$$

where $P_{YG4\text{-}5}$ is the yield grade 4-5 discount and other terms are as described above.

A group of specific models based upon the general specification of (1) and (2) were examined. Initial estimation was with Proc Reg in SAS (SAS Institute), followed by a battery of misspecification tests, joint conditional means (JCM) and joint conditional variance (JCV) tests (McGuirk, Driscoll, and Alwang). Final estimation of the model with simultaneous corrections for other problems was done with Proc Autoreg in SAS.

The errors were expressed as an autoregressive process. Final estimation was with Proc Reg.

One model was a straightforward specification from equations (1) and (2). The Choice-Select discount was modeled as

(3) $$\text{PCh-Sel}_t = f(\text{PBoxBf}_t, \text{Prodn}_t, \%\text{ Ch}_t, \%\text{YG4-5}_t, \text{dMPR}, \text{dSeas}_j),$$

where PCh-Sel is the Choice-Select discount in time t, PBoxBf is the price of boxed beef in time t, Prodn is federally inspected beef production in time t, % Ch is the percent Choice in the slaughter mix in time t, %YG4- is the percent yield grade 4-5 in the slaughter of time t, dMPR is a zero-one dummy variable measuring structural shift at the point of MPR; and dSeas is a binary dummy variable representing seasonal effects for month j, $j = 1,\ldots,12$.

The comparable model for the yield grade 4-5 discount was

(4) $$\text{PYG4-5}_t = f(\text{PBoxBf}_t, \text{Prodn}_t, \%\text{ Ch}_t, \%\text{YG4-5}_t, \text{dMPR}, \text{dSeas}_j),$$

where PYG4-5 is the yield grade 4-5 discount in time t and other variables are as defined above.

A second model was a partial adjustment model with two-period lags on the dependent variables. The Choice-Select discount was modeled as

(5) $$\text{PCh-Sel}_t = f(\text{PCh-Sel}_{t-1}, \text{PCh-Sel}_{t-2}, \text{PBoxBf}_t, \text{Prodn}_t, \%\text{ Ch}_t, \%\text{YG4-5}_t, \text{dMPR}, \text{dSeas}_j)$$

and the comparable yield grade 4-5 model was

(6) $$\text{Pyg4-5}_t = f(\text{Pyg4-5}_{t-1}, \text{Pyg4-5}_{t-2}, \text{PBoxBf}_t, \text{Prodn}_t, \%\text{ Ch}_t, \%\text{YG4-5}_t, \text{dMPR}, \text{dSeas}_j),$$

with all variables defined above.

The final model for each dependent variable is a reduced form of equations 5 and 6. Only economic factors thought to be most important are included. They are

(7) $\text{PCh-Sel}_t = f(\text{PCh-Sel}_{t-1}, \%\ \text{Ch}_t, \text{dSeas}_j)$, and

(8) $\text{Pyg4-5}_t = f(\text{Pyg4-5}_{t-1}, \%\text{YG4-5}_t, \text{dSeas}_j)$.

After performing the battery of statistical tests, models 5 and 6 were deemed best so will be discussed here. The other individual models suffered from a myriad of econometric problems, e.g. structural change in the mean equation, non-linearity of the parameters, autocorrelation, and static and dynamic heteroscedasticity.

The partial adjustment models have an intuitive appeal as they imply quantities and prices adjust slowly over time to new market conditions and market information (Carlberg and Ward). This slower adjustment process is oft used as justification for including lagged dependent variables in an empirical model. It can be argued that given some exogenous shock occurring in this market, there will a price adjustment in time period t-2 and another in time period t-1, bringing about the full adjustment by time t.

Models 5 and 6 were subjected to the battery of misspecification tests as indicated above. Full results of test results can be found in Hogan. Tests indicated a structural change in the mean equation and autocorrelation in model 5, the Choice-Select model. A structural change variable was added to the midpoint of the series and the final model was estimated with Proc Autoreg. Dynamic heteroscedasticity was not corrected, leaving the estimators unbiased and consistent but not efficient.

For the yield grade 4-5 model, it was also necessary to correct for selected problems. Non-linearity in the parameters was corrected by using a squared term on the first partial adjustment variable. The binary structural change variable dealt with a

structural change in variance when MPR began. Final modeling was conducted with Proc Autoreg, simultaneously modeling the error terms as an autoregressive process. Static heteroscedasticity was not addressed, leaving the estimator inefficient but unbiased and consistent. The assumed cause of the non-constant variance is the data series change caused by MPR.

Estimation Results

Coefficient estimates for the Choice-Select discount (model 5) and yield grade 4-5 discount (model 6) are presented in Table 2.

Choice-Select - Both partial adjustment terms were significant. Since the Choice-Select discount is almost always negative, the positive sign on the term at time t-1 is expected. The term at lag t-2 has a positive sign but having lags with alternating signs is also expected. The significance of these two terms could be seen as inertia in the quality market for different grades of beef. Quantity of yield grade 4-5 in this period's production is significant with the expected sign. As the number of these lower yielding cattle increases, the number of Choice and Prime cattle in the pen increase giving a greater percent of Choice and causing the Choice-Select discount to narrow or become smaller in absolute value. The price of boxed beef is significant with the expected sign. The negative sign implies that as the price of boxed beef increases, it would be expected to see cattle sold out of feedlots with fewer days on feed, hence percent Choice would decrease and the discount would widen or become more negative. The structural change variable was significant, indicating a narrowing of the Choice-Select discount at the midpoint of the data series, about when MPR began. The seasonal pattern found suggests a greater negative impact on the Choice-Select discount during April and September

compared with December. Prior research has shown demand for both beef quality grades, Choice and Select, becomes more inelastic during the second and third quarters and these two grades are not substitutes for one another during these quarters (Lusk et al.). These are considered to be "grilling" months. At this time of year, retailers may adjust their offerings to accommodate changes in consumer tastes and preferences. Lusk et al. further show that during the first and fourth quarter Choice and Select beef are substitutes for one another. Thus it might be expected to see the pattern in the quality discount follow this same pattern.

Yield grade 4-5 - All yield grade discount models had substantial econometric problems. However, given results of the statistical test indicating that this series is not equal in mean or variance before and after the inception of MPR, it is probably not surprising to find fairly poor results of these regressions. The two partial adjustment terms are significant and have the expected signs. Structural change in the series occurred as evidenced by the coefficient on the structural change variable. The negative sign is consistent with prior tests for changes in the series when MPR began. Significant seasonal coefficients were found for several months (February, March, August, September, and October). All four autoregressive terms are significant, suggesting it may benefit from additional partial adjustment terms as there appears to be substantial inertia in this market.

Summary and Conclusions

An objective of this study was to determine the factors explaining the Choice-Select and yield grade 4-5 discounts for beef carcasses. Results show a partial adjustment model with two lags best describes these two discount components. With respect to the quality discount, partial adjustment coefficients, percent of yield grade 4-5

and boxed beef price describe the structure. An increase in the boxed beef price will cause feeders to market their cattle sooner to take advantage of the price. This action will lead to a smaller percentage of yield grade 4-5 cattle and a larger quality discount.

The yield grade model is made up of the statistically significant two partial adjustment terms and the structural change term. It is intuitive that this discount is a penalty or economic disincentive to feed cattle to higher yield grades. Thus, it may be more believable to see this discount as a continually moving partial adjustment process or an autoregressive process. The discontinuity in the yield grade series makes the modeling process more obscure than it otherwise might be.

Seasonality is evident in both quality grade and yield grade discount models. The seasonality in the Choice-Select discount indicates a smaller relative discount in the first and fourth quarters of the year and larger relative discounts in the second and third quarter. These findings suggest during the second and third quarter, encompassing summer grilling months, that Choice and Select beef are not substitutes for one another. The second possible implication relates to the timing of production. Calves born during springtime calving will be weaned in the early fall, put on wheat through the following winter, and then moved to the feedlot during the first weeks of March. These cattle should be finished and ready to sell in August, September, and October. This would give buyers enough supply to be selective when making procurement bids. Thus it would be possible to sustain a greater discount for better quality grade.

The seasonal terms of the yield grade 4-5 model are less easy to understand. It is economically intuitive these terms should “mirror” the quality grade terms. While this

seems to be the case through May or June, then it seems to become directly related to the quality terms.

Exogenous forces occurred in the carcass beef market with the advent of MPR on April 3, 2001. Statistical tests show both quality and yield grade discounts changed in variance and the yield grade 4-5 discount changed in mean also. All models estimated for both discount series exhibit numerous econometric problems. Some of these may be attributable to the switch to MPR.

In conclusion, if a producer markets fed cattle on a grid, there appears to be an advantage in the first quarter of the year for cattle likely to grade a higher percentage of quality grade Select. For heavier cattle more likely to contain a higher percentage of yield grade 4-5 carcasses, a producer would appear to benefit with an anticipated marketing date in the second quarter.

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Table 1. Summary Statistics Before and After Mandatory Price Reporting, April 3, 2001

		Before MPR	After MPR
Choice-Select discount ($/Cwt.)			
	Mean	-7.6091	-7.9643
	Standard deviation	3.1920	2.3682
	Minimum	-14.5800	-16.0000
	Maximum	-2.0000	-3.9200
	Skewness	-0.1768	-0.9585
	Kurtosis	-0.7087	1.9471
Yield grade 4-5 discount ($/Cwt.)			
	Mean	-15.4867	-12.0527
	Standard deviation	1.7715	1.0294
	Minimum	-19.5000	-16.5000
	Maximum	-11.4300	-10.7500
	Skewness	0.3397	-2.3184
	Kurtosis	0.1868	6.4094

Table 2. Model Results for Choice-Select and Yield Grade 4-5 Discounts.

Variable	Choice-Select	Yield Grade 4-5
Intercept	-1.7550	-2.6559*
	(1.1287)	(1.3875)
Choice-Select discount t-1	1.6706**	NA
	(0.0516)	
Choice-Select discount t-2	-0.7429**	NA
	(0.0491)	
Yield grade 4-5 discount t-1[2]	NA	-0.0141**
		(0.0034)
Yield grade 4-5 discount t-2	NA	0.5114**
		(0.0958)
Percent Choice	4.7105**	-0.7533
	(1.6072)	(1.8490)
Percent YG4-5	-3.4387	-0.3398
	(2.8433)	(5.1220)
Price of boxed beef	-0.0110**	-0.0027
	(0.0033)	(0.0041)
Production	-0.00011	-0.0012
	(0.0010)	(0.0009)
Structural change	0.1838**	0.4377**
	(0.0690)	(0.1339)
January	0.1199	-0.2163
	(0.1058)	(0.1357)
February	0.0092	-0.3855**
	(0.1132)	(0.1415)
March	0.1086	-0.2981**
	(0.1096)	(0.1350)
April	-0.2681*	-0.0028
	(0.1138)	(0.1363)
May	-0.0338	-0.1570
	(0.1206)	(0.1406)
June	0.0356	-0.0807
	(0.1078)	(0.1432)
July	-0.0511	-0.1856
	(0.1015)	(0.1348)
August	-0.0633	-0.4104**
	(0.1143)	(0.1362)
September	-0.1938*	-0.5959**
	(0.1135)	(0.1390)
October	-0.0787	-0.3099**
	(0.1174)	(0.1376)
November	-0.0684	-0.2076
	(0.1048)	(0.1338)

Variable	Choice-Select	Yield Grade 4-5
December	Base	Base
AR1	0.6487**	-0.3763**
	(0.0750)	(0.1100)
AR2	0.3526**	0.5010**
	(0.0885)	(0.1048)
AR3	0.1613**	-0.2709**
	(0.0698)	(0.0863)
AR4	NA	0.2062**
		(0.0863)
R2	0.9603	0.9652
AIC	605.8078	392.8757
Log Likelihood	-280.9039	-170.4379

Notes: Standard errors are given in parentheses. Single and double asterisks (* and **) denote significance at the 0.10 and 0.05 levels, respectively.