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by

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Abstract

The effect of carcass quality uncertainty on the structure of the slaughter cattle market is investigated. A theoretical extension of the "Theory of Factor Price Disparity" is provided. It is demonstrated that the coexistence of a risk premium wedge between pricing mechanisms (live wt., dressed wt., and grid) in conjunction with varying degrees of risk aversion across fed cattle producers explains the coexistence of multiple pricing mechanisms. It is also demonstrated that risk and risk preference provides a plausible explanation for the structure of the fed cattle market and for the variability in slaughter volume across marketing channels. Empirical evidence is provided in support of the supposition that carcass quality uncertainty plays a role in grid market share variability.

Uncertainty and Producer Fed Cattle Marketing Decisions: Theory and Evidence

Fausti and Feuz (1995) proposed the "Theory of Factor Price Disparity (TFPD)" as plausible explanation for the existence of a price wedge between the pricing mechanisms associated with the marketing channels of live wt., dressed wt., and grid for slaughter cattle.[1] Fausti and Feuz's theoretical model demonstrates that incomplete information on carcass quality will result in packers charging a risk premium to compensate for bearing the uncertainty over carcass quality when purchasing slaughter cattle by the pen at an average price per hundred wt. (cwt.), relative to purchasing cattle on an individual basis using a grid pricing mechanism.[2] Fausti and Feuz (1995), and Feuz et al. (1995) provide empirical evidence that varying the degree of incomplete information on carcass quality will change the level of risk premium charged, i.e., the less information on carcass quality, the higher the risk premium. Numerous empirical studies have reported statistical evidence supporting the existence of this price differential phenomenon across marketing channels for slaughter cattle (e.g., Fausti et al. 1998; Schroeder and Graff 2000; Anderson and Zeuli 2001; and Fausti and Qasmi 2002). Furthermore, White et al. (2007) empirically documented the presence of a feeder cattle market risk premium that is consistent with the TFPD.

Fausti and Feuz hypothesize that the observed marketing behavior of producers selling slaughter cattle is driven by risk preference. Fausti and Feuz (p. 534) state: "We conclude that the coexistence of the three marketing alternatives with price disparity is the result of sellers having varying degrees of risk aversion." The economic implication of this supposition is that without the "varying degrees of risk aversion" assumption the three marketing channels would collapse to one, assuming a competitive market. The literature to date supports the Fausti and Feuz view that TFPD and the variation in risk preferences across producers is a plausible explanation for the coexistence of the marketing channel alternatives of selling fed cattle either live weight or dressed weight by the pen at an average price, or selling cattle on an individual basis on a grid.

While the literature has numerous studies providing evidence of the existence of a price differential, and the coexistence of the three pricing mechanism remains the only empirical evidence of the role that seller risk preference plays in the producer's decision to market slaughter cattle by the pen at an average price versus selling on a grid. The goal of this study is to extend this literature by providing a simple theoretical framework that investigates the consequences of producer (seller) risk preference on fed cattle marketing decisions. Empirical evidence of risk preference affecting producer marketing behavior at the national level is provided.

Theoretical Framework:

Assume that a fed cattle producer's marketing channel selection decision is influenced by his/her preference for risk. Let us further assume that all sellers of fed cattle are risk-averse. Assume a producer negotiates with multiple packers and receive bids for selling their cattle live weight by the pen and the seller also receives bids on a grid base price, but carcass premiums and discounts are based on a weekly pricing schedule that is public information. As a result of the negotiations, both the buyer and seller have formed ex ante expectations concerning the average carcass quality of the slaughter cattle being offered for sale.

If the seller decides to sell his/her cattle by the pen at a live weight price (P_L), then the price per cwt. paid to the seller is known with certainty. In this case, however, the packer assumes the risk associated with carcass quality uncertainty (Feuz et al. 1993: p. 455) because the packer assumes ownership prior to slaughter.[3] If the seller selects to market cattle on a grid then the seller is uncertain about the final price per cwt. received. The uncertainty is due to carcass quality, i.e., the price per cwt. is not established until after carcass quality has been assessed.

From the seller's perspective, there is a positive probability (γ) that the average grid price per cwt. paid will be lower than the live weight price per cwt. (P_L) due to unexpected negative carcass characteristics that result in the levying of discounts. If this should occur, then the seller's average price per cwt. will be P_1. However, there is also a positive probability ($1-\gamma$) that the average grid price per cwt. will be higher than the live weight price due to unexpected positive carcass characteristics that result in the levying of premiums.[4] In this case the seller's price per cwt. will be P_2, i.e., $P_2 > P_L > P_1$. The expected value of the seller's cattle marketed through a grid is:

1. $E(P_G) = \gamma P_1 + (1-\gamma)P_2$.

Risk Aversion and Seller Marketing Decisions

The first issue to be investigated is the effect of price disparity on the producer's marketing channel decision. We begin by assuming that price disparity is absent, i.e., $E(P_G) = P_L$. Assume a univariate utility function $U(P_i)$ that exhibits diminishing marginal utility with respect to price per cwt.: $dU/dP_i > 0$, $d^2U/dP_i^{\ 2} < 0$; were i= G or L. Thus the seller has a concave utility function with respect to outcomes for the two marketing alternatives. For the grid marketing alternative, the utility of expected value is:

2. $U[E(P_G)] = U[\gamma P_1 + (1-\gamma)P_2]$.

The Expected Utility function for marketing on the grid is:

3. $E[U(P_G)] = \gamma U(P_1) + (1-\gamma)U(P_2)$.

According to the economics of uncertainty literature (e.g., Robison and Barry 1987) for the risk-averse agent: $U[E(P_G)] > E[U(P_G)]$. Given the assumption; $E(P_G) = P_L$, then $U(P_L) = U[E(P_G)] > E[U(P_G)]$. This implies the risk-averse seller requires a positive risk premium payment "θ" to sell on a grid: $E(P_G) - P_L \geq \theta$. The bracketed term in equation 4 is defined as the "coefficient of absolute risk aversion (R_A)" and according to Pratt (1964), θ is defined as:

4. $\theta = \frac{1}{2} \frac{-U'' \; P_G}{U' \; P_G} \quad \sigma^2_{P_G}.$

We will also assume that the fed cattle market contains a continuum of identical producers except with respect to risk preference. Thus the market contains a set of producers (ordered set S) and each producer has a unique correspondence of risk preference (U'') to risk premium (θ). It is assumed that a random subset of producers is selling slaughter cattle in the market at any point in time:

5. $S \ni \; (U'', \theta) \;\big|\; \theta \; = \; \frac{1}{2} \; \frac{-U'' \; P_G}{U' \; P_G} \quad \sigma^2_{P_G}$.

The size of the risk premium will vary positively with the level of seller risk aversion ($U''<0$). If the premium is not large enough to overcome the seller's aversion to risk, then the seller will market his/her cattle by the pen at an average price. A simple graphical model of a seller's utility function U(P) is provided in Figure 1 to supplement additional discussion.

In Figure 1, a representative seller's utility function with respect to marketing cattle is denoted as U(P).[5] The vertical axis reflects a level of utility and the horizontal axis represents price per cwt. Prices P_1 and P_2 are identified in Figure 1 on the horizontal axis. The corresponding levels of utility $U(P_1)$ and $U(P_2)$ are denoted as points A and B on the seller's utility function, respectively. The expected value associated with the seller's decision to sell cattle on the grid is given by eq. 1, and is denoted as $E(P_G)$ on the horizontal axis in Figure 1. Expected utility (eq. 3) is denoted by point C on the line segment $\overline{AB}$. The certainty equivalent level of utility associated with point C is the level of utility given by point D. Utility of expected value (eq. 2) is denoted by point E on the seller's utility function. Point E also reflects the seller's level of utility if the seller decides to market his/her cattle at a live weight price: $U(P_L)$. This is the seller's certainty (no risk) marketing alternative. The certainty equivalent price per cwt. associated with point D is P^*. For the risk-averse seller, P^* is the certainty equivalent value of the risky marketing alternative $E(P_G)$. Given the assumption of $E(P_G) = P_L$, the price differential of $E(P_G) - P^*$ is the risk premium (θ) the risk-averse seller would require before they would be willing to consider selling their cattle on a grid rather than selling their cattle by the pen at a live weight price.

The economic implications of the simple theoretical framework depicted in Figure 1 for the seller are: a) if $E(P_G) = P_L$, then a risk-averse seller will only sell cattle by the pen, at a live weight price, and b) as the representative seller becomes less risk-averse, i.e., as U'' approaches zero, the limit of the risk premium "θ" approaches zero.[6] This implies a risk-neutral seller will be indifferent between the grid and live weight marketing alternatives at $\theta=0$.

The economic analysis provided in Figure 1 leads to the following proposition:

Proposition 1: *In the absence of price disparity, varying the degree of risk aversion across sellers will not sustain the coexistence of multiple marketing channels for slaughter cattle. All risk-averse sellers will only sell cattle by the pen, at a live weight price. The coexistence of multiple marketing channels will only occur if a subset of sellers is risk-seeking.*

Proposition 1 is based on the assumption sellers have the expectation that they will, on average, receive the same price per cwt. for their cattle whether they sell live weight or on a grid. The implication for grid market share of slaughter volume derived from proposition 1 is that only risk-seeking producers will market their cattle on a grid. Recent estimates indicate that 44.3

percent of slaughter cattle marketed in 2009 was sold on a grid (Fausti et. al. 2010: Table 7). The conclusion that a large proportion of fed cattle producers are risk-seeking is suspect.

Price Disparity, Risk Aversion, and Seller Marketing Decisions

As discussed earlier, Fausti and Feuz's TFPD indicates that price disparity alone is not enough to explain the coexistence of multiple marketing channels for slaughter cattle. The introduction of price disparity into the analysis is accomplished by assuming $E(P_G) > P_L$. Fausti and Feuz (pp. 537-38) demonstrate that a risk-neutral packer will charge a positive risk premium and this premium will increase as a packer becomes more averse to risk when buying cattle by the pen at an average price. Incorporating packer behavior toward carcass quality uncertainty into the analysis requires that the packer to offer a live weight price to sellers that embodies a risk premium (λ). From the packer's point of view, the expected value of a pen of cattle being purchased live weight is $E(P_G)$. However, the live weight price the risk-neutral packer offers according to TFPD is $E(P_G) = P_L - \lambda = P_{L\lambda}$. $P_{L\lambda}$ now reflects the price associated with the seller's marketing alternative under certainty.

The introduction of price disparity "λ" into analysis relaxes our initial assumption of $E(P_G) = P_L$. We are now assuming that: a) packers are charging a risk premium if they have to purchase a producer's cattle live weight, and b) all producers are aware that the expected value of selling cattle on a grid is greater than the live weight price per cwt.

In Figure 2, $U(P_{L\lambda})$ is denoted as point F and is located to the left of point E on the seller's utility function. On the horizontal axis, $P_{L\lambda}$ denotes the seller's marketing alternative with price certainty. The introduction of λ alters the risk premium a seller would require to switch from selling live weight to selling on a grid:

6. $[E(P_G) – P^*] – [E(P_G) - P_{L\lambda}] = \theta-\lambda$.

The risk premium the seller now requires is θ-λ, and it reflects the differential in what the seller is willing to pay to avoid marketing on a grid (θ) and the risk premium the packer levies when the producer sells live weight (λ). We now refer to θ-λ as the market risk premium. Note, if $\lambda>\theta$, then all risk-averse producers will sell their cattle on a grid.

The economic implications of the simple theoretical framework depicted in Figure 2 for the risk-averse seller are: a) if all sellers have identical risk preferences, then only a single marketing channel will exist, if θ-λ >0 (θ-λ < 0: implies $P^* > P_{L\lambda}$) then only the live (grid) marketing channel will exist, b) in set S, as a producer becomes less risk-averse, i.e., as U'' approaches zero, the risk premium "θ-λ" this producer requires to sell on a grid approaches -λ. This implies a risk-averse seller will be indifferent between the grid and live weight marketing alternatives when $\theta=\lambda$ ($P^* = P_{L\lambda}$), c) a risk-neutral seller would be willing to pay up to λ to market on the grid rather than sell live weight,[7] and d) the existence of λ in conjunction with varying degrees of risk aversion among producers explains the coexistence of multiple marketing alternatives for slaughter cattle.

Proposition 2: *if price disparity is present and risk aversion varies across sellers, then multiple marketing channel alternatives and their associated pricing mechanisms will coexist in the slaughter cattle market.*

In tandem, propositions 1 and 2 clearly identify the economic basis for the coexistence of multiple marketing channels is the result of the effect of carcass quality uncertainty on market participant behavior. The coexistence of the risk premium wedge between pricing mechanisms with varying degrees of risk aversion across fed cattle producers explains the coexistence of multiple marking channels for fed cattle. While Fausti and Feuz state that "price differentials" were not enough to explain the existence of multiple marketing channels, they did not flesh out the symbiotic relationship between the coexistence of a price wedge and variation in the level of risk aversion across sellers. We demonstrate that both conditions are required for the coexistence of multiple marketing channels.

Comparative Statics: A Change in Carcass Quality Uncertainty

In Figure 2, a change in a risk-neutral packer's perceived level of risk associated with uncertainty surrounding carcass quality will alter the value of λ (Fausti and Feuz: p. 538). In this case, the seller views this as an exogenous change in the market. For example, an increase in packer uncertainty over carcass quality will increase λ and shift $P_{L\lambda}$ to the left. In this case, a decline in θ-λ will cause some risk-averse sellers in set S who were selling live weight to shift to marketing on the grid as the market premium declines.

The economic implication for risk-averse sellers is: if the packer perceives an increase in carcass quality uncertainty and θ-λ >0, then the packer will increase λ to compensate for the additional risk burden. As a consequence, some proportion of the less risk-averse cohort of producers who were selling live weight will now sell on the grid. This can easily be demonstrated by remembering that equations 4 and 5 represent a mapping of the functional relationship between U'' and θ: f: $U'' \rightarrow \theta$. An increase in λ results in a decline in the market risk premium required by sellers (θ-λ) to market on the grid. The reduction in the disincentive to market on a grid is due to the increase in the risk premium the producer must pay to market live weight, i.e., the certainty alternative. Therefore, if a producer was indifferent (λ=θ) to marketing on a grid versus live weight prior to the packer increase in λ, after the increase this producer will select the grid marketing alternative.

Proposition 3*:* *In the presence of price disparity and variation in risk aversion across sellers, a change in buyer-perceived risk due to a change in carcass quality uncertainty will cause a shift* *in slaughter volume market share across marketing alternatives (live, dressed, and grid) as sellers respond to the packer adjusting the risk premium to compensate for the change in risk.*

Proposition 3 raises an interesting policy issue. If packers had significant market power, then packers could raise the λ associated with pen level purchases without experiencing an increase in carcass quality uncertainty. This action, in turn, would result in a positive market signal to producers with respect to marketing on a grid. This positive market signal would increase grid market share. This type of pricing behavior could lead to a "lemon market" outcome as described in the Western Organization of Resource Councils 1997 petition to the USDA (Federal Register: January 14, 1997; p. 1847).

The difficulty in providing empirical evidence in support of proposition 3 is the inability to concisely measure risk premiums. Feuz et al. (1995) estimates risk premiums associated with the live, dressed, and grid (Grade and Yield) marketing alternatives and finds positive risk premiums consistent with TFPD. They also calculate an estimate for the packer's coefficient of absolute risk aversion. However, their analysis is for a single period. Testing proposition 3 would require time series data on risk premium and grid market share.

A corollary to proposition 3 follows:

Corollary 1: *In the presence of price disparity and variation in risk aversion across sellers, a change in seller-perceived risk due to a change in carcass quality uncertainty will increase the level of the seller's required risk premium to market on a grid. The increase in the seller's risk premium requirement will cause a shift in slaughter volume market share across marketing alternatives (live, dressed, and grid).*

The effect of a seller's perceived increase in risk over the market value of his/her cattle due to increased carcass quality uncertainty is investigated in Figure 3. To simplify the analysis it is assumed that seller perceives increased risk as a mean-preserving symmetric increase in the distribution of P_G. This assumption is consistent with economics of uncertainty literature, e.g., Sandmo (1971). Increased risk is introduced in Figure 3 as an increase in the range of price outcomes associated with grid premiums and discounts: $P_4 > P_2 > P_1 > P_3$. A mean-preserving shift in dispersion implies that γ, the probability of a carcass discount, is unchanged.

In figure 3, the increase in risk associated with marketing on a grid will result in the downward parallel shift in the expected utility curve (line segment $\overline{GH}$). Point I now denotes the level of expected utility associated with the seller's perception of increased risk associated with grid marketing. The certainty equivalent level of utility associated with point I is the level of utility given by point J. The certainty equivalent price per cwt. associated with point J is P^{**}. Evaluating this change in risk using equation 6, the risk premium now required by the producer to market on the grid has increased from $P_{L\lambda} - P^*$ to $P_{L\lambda} - P^{**}$ (ie., $(\theta_1\text{-}\lambda) > (\theta\text{-}\lambda)$). Assuming the level of risk aversion varies amount sellers, the increase in the market risk premium (i.e., $\theta_1\text{-}\lambda$) required by sellers to market on the grid will result in fewer sellers marketing on the grid. Fewer producers electing to market on the grid will reduce grid market share of slaughter volume. We conclude that risk and risk preference provides a plausible explanation for grid market share variability and by extension the variability in slaughter volume market share occurring in the live wt., and dressed wt., marketing alternatives.

A corollary to the "Theory of Factor Price Disparity" is established by the paper's three propositions and corollary 1.

TFPD Corollary: *A risk-averse competitive firm selling a heterogeneous product with respect to quality will accept a lower price for that product in a market where quality remains uncertain at* *the time of the transaction rather than selling it in a market where quality is known with certainty at the time of transaction.*

The contribution of the TFPD and the TFPD Corollary is the provision of a plausible explanation for the coexistence of multiple equilibria for a single commodity, slaughter cattle. Thus, in the presence of carcass quality (product) uncertainty, risk and risk preference explains the existence of multiple market equilibria for single commodity (slaughter cattle) when buyers and sellers face symmetric incomplete information on product quality.

The TFPD poses an interesting question with respect of the relationship between market power and market structure. The game theory literature on "bargaining with two-sided incomplete information" discusses the consequence of one player having greater bargaining strengthen. The stronger player is more likely to capture gains from bargaining (Catterjee and Samuelson 1987). Given the current structure of the fed cattle market, this issue is a potential avenue for future research.

The task of empirically testing Corollary 1 confronts the same obstacles as proposition 3. However, recent empirical studies by Lange (2009) and Fausti et al. (2011) on steer and heifer grid market share provides an opportunity to test the validity of Corollary 1. In the next section, the economic implications of cattle gender are discussed with respect to fed cattle marketing. The empirical and summary sections follow.

Gender, Carcass Quality, and Marketing Risk:

Carcass Quality

The animal science has extensively investigated the effect of gender on slaughter cattle carcass quality. Garcia et al. (2008) discusses the findings of the 2005 National Beef Quality Audit with respect to carcass quality and gender. They found no statistical difference in USDA yield grade, quality grade, marbling score, % KPH, and adjusted fat thickness with respect to gender. According to Tatum, Gruber, and Schneider (2007: p. 3), the empirical evidence indicates that "Despite the fact that heifers typically produce carcasses with higher marbling scores and more desirable USDA quality grades, product tenderness usually favors steers.…" A similar finding on steer vs. heifer yield and quality grades is reported by Choat et al. (2006) and Zinn et al. (2008). In a study published by Certified Angus Beef ™ (CAB) based on data for approximately 19.8 million carcasses marketed between 1999 and 2005, Corah and McCully (2006) reported that the percentage of heifers grading prime or choice were on average ten percentage points higher than steers. The data indicates that average heifer quality grade, for this time period, was superior for CAB program qualifying slaughter cattle. Significant research on gender and carcass quality by animal scientists indicates that the average quality of slaughter heifer carcasses is at least equal or superior to slaughter steers with respect to USDA yield and quality grades.

Heifer Carcass Issues

Slaughter heifers, however, do have carcass quality issues specifically associated with gender. Schultz and Marsh (1985) discuss lighter carcass weights and pregnancy as issues that may negatively affect slaughter heifer market value relative to slaughter steers. Pregnancy negatively affects dressing percentage, 2 to 3% on average (e.g., Bishop et al. 2003).

Voisinet et al. (1997) found that gender has a statistically significant effect on the incidence of a carcass being graded as a dark cutter. Voisinet reported that the incident of "dark lean color" increased from 3.1% for steers to 11.1% for heifers. Scanga et al. (1998) reported dark cutter incident data from the 1995 National Beef Quality Audit report which indicated that implanted steer dark cutter incidence ranged from 0.5% to 2% and for implanted heifers the range was higher at 3.5% to 5.2%. A carcass will receive a sizable discount if graded as a dark cutter, and represents an additional financial risk to producers who sell slaughter heifers on a grid relative to slaughter steers.

The animal science literature has also looked at the issue of the effect of heifer pregnancy on dark cutter incidence and carcass quality. The relationship between slaughter heifer pregnancy status and dark cutter incidence rate was investigated by Kreikemeier and Unruh (1993). In the Kreikemeier and Unruh Kansas feedlot study the pregnancy rate was about 4.74%. The following categories (p. 1702: Table 2) were statistically different between pregnant and non-pregnant heifers: a) pregnant heifers had a lighter carcass weights (approximately 10 pounds), b) pregnant heifers had a greater level of fat thickness (.11cm), c) pregnant heifers had a higher quality grade, and d) pregnant heifers had a lower level of darker cutter incidence. Kreikemeier and Unruh conclude: "Any apparent economic advantage of a higher quality grade and lower occurrence of dark cutters for pregnant heifers may be offset because they have more backfat and probably a lower dressing percentage." The implication of Kreikemeier and Unruh's research is that the economic risk associated with heifer carcass quality may be very similar for open and pregnant heifers.

Heifer Marketing Risk

Schultz and Marsh (1985) discuss the perceived price differential between slaughter steers and heifers. They discuss the likely reasons for this perception: a) lighter finishing weights for heifers and b) random factors such as packer gender preferences. Schultz and Marsh (p. 85) report that they find no statistical evidence that there is a "finished steer minus finished heifer price differential" using U.S. quarterly data (Table 4: insignificant intercept coefficient).

Famínow, de Matos, and Richmond (1996) investigate if a gender pricing bias exists when marketing steers relative to heifers' live weight versus actual carcass value (the market value of cut, trim, and waste) to a Canadian packer. They reported that steers sold live weight were overpaid their market value with respect to actual carcass value. Heifers sold live weight, however, were underpaid the market value of their actual carcass value. This study suggests that when heifers are sold live weight at an average price per pen versus slaughter steers; producers are willing to pay a higher risk premium to packers for the right to sell live weight.

The issue of a gender effect on producer marketing decisions was first discussed by Lange (2009). Lange adopted an approach developed by Fausti et al. (2010) to estimate individual weekly market share for steer slaughter volume across marketing alternatives. Lange investigated the issue of a gender effect on producer marketing decisions by analyzing grid market share of slaughter volume. For the period from April 11, 2004 to January 11, 2009, Lange found that, on average, 41.58% of slaughter steers versus 33.20% of slaughter heifers were sold on a grid. Lange's results indicate that producers have a stronger propensity to sell their slaughter heifers by the pen at an average price relative to their slaughter steers. Lang's results are consistent with the hypothesis proposed in Corollary 1. In the next section, an empirical investigation of Corollary 1 will be conducted.

Empirical Framework:

Empirical Hypothesis

The animal science literature (discussed above) indicates that carcass quality for steers and heifers is very similar and on average there is evidence heifer quality grade is superior. However, heifers have a higher risk of negative carcass quality events, i.e., pregnancy and dark cutter. This implies a higher level of dispersion in carcass value for heifers relative to steers. In addition the literature indicates an economic tradeoff between pregnancy and dark cutter/quality grade outcomes for heifers. Given the research reported in the animal science literature, we will assume that $E(P_G)$ for steers and heifers are equivalent. The level of dispersion associated with P_G, however, is assumed to be higher for heifers as a result of the pregnancy/dark cutter issue. In Figure 3, that would be reflected by shifting of the expected utility curve from $\overline{AB}$ to $\overline{GH}$, where $\overline{AB}$ represents the expected utility curve for marketing steers on a grid and $\overline{GH}$ represents marketing heifers on a grid. If the live weight price, which is the marketing alterative with price certainty ($P_{L\lambda}$), is assumed to equal for slaughter steers and heifers, then Corollary 1 predicts that grid market share will be higher for slaughter steers relative to slaughter heifers. [8]

Empirical Methods

Grid market share for heifers and steers is analyzed to determine if there is evidence to support our theoretical proposition that carcass quality uncertainty effects producer marketing channel select decisions for fed cattle. Following the work of Lange (2009), we provide estimates for weekly grid market share of slaughter volume for slaughter steers and heifers. The time period is from April 11, 2004 - May 2, 2010. We have also collected the AMS reported weekly average live weight price for steers and heifers for the same time period.

Non-parametric hypotheses tests are conducted to determine if there is statistical evidence to support the two hypotheses: a) steer and heifer live weight prices are not statistically different, and b) grid slaughter volume market share is statistically higher for steers relative to heifers.

Data

The sources of the data used in this study are the USDA-AMS weekly reports (2004-2010); series LM_CT154 and LM_CT151. The LM_CT154 (National Weekly Direct Slaughter Cattle) covers slaughtered cattle that were purchased using a negotiated price. Conversely, series LM_CT151 (National Daily Direct Slaughter Cattle – Formulated and Forward Contract

Purchases – Domestic) reports the breakdown of non-negotiated purchases, both formulated and forward contract purchases. These reports include slaughter volume, dressing percentage, weight range, price range, and weighted average price. The weekly average live weight price for steers and heifers was collected from the LM_CT150 (5- Area Weekly Weighted Average- Live FOB Basis). All data was retrieved from the Livestock Marketing Information Center. Methodology for calculating grid market share of slaughter volume can be found in Lange (2009) and Fausti et al. (2010).

Empirical Tests and Results

A simple “Difference in Population Means: Matched Pairs Test” was conducted. The parametric paired difference means test requires the distribution of the paired differences to be normally distributed (Newbold 1995: p. 353). The Anderson-Darling test was conducted and the null hypothesis that the distribution of paired differences is normally distributed was rejected for both the grid market share data and the live weight price data (Gujarati 2003: p.147) at the 5% level. The Wilcoxon Signed Rank Test (large sample) for matched pairs was selected to test the null hypothesis: the distribution of matched paired differences is centered on zero (Newbold 1995: p. 391). Two hypotheses tests are proposed:

Hypothesis Test I: The null hypothesis states that the distribution of matched paired differences for steer minus heifer live weight price is centered on zero. The alternative hypothesis is that the distribution of paired differences is not centered on zero.

Hypothesis Test II: The null hypothesis states that the distribution of matched paired differences for steer minus heifer weekly grid market share of slaughter volume is centered on zero. The alternative hypothesis is that the distribution of paired differences is greater than zero.

The Proc Univariate SAS procedure (Schlotzhauer and Littell 1987) was selected to conduct the empirical analysis. Table 1 contains the summary statistics for steer and heifer grid market share, and for the weekly steer and heifer live weight price. Table 2 contains the results for Wilcoxonian statistical tests.[9]

Table 1. Summary Statistics: April 11, 2004 - May 2, 2010

Variable	No. of Obs.	Mean	Standard Deviation	Minimum	Maximum
Heifer Live Price	317	88.33	5.27	78.20	101.39
Steer Live Price	317	88.26	5.26	78.24	101.18
Heifer Grid % Share	317	33.02	5.09	20.20	47.78
Steer Grid % Share	317	42.25	5.28	28.88	61.22

Table 2. Wilcoxon Test Results: Difference in Population Means: Matched Pairs Test

Variable	No. of Obs.	Mean	Standard Deviation	Range	p-value
Steer minus Heifer Live wt. ($ cwt.)	317	-0.07	0.134	0.89	.0001
Steer minus Heifer %Grid Market Share	317	9.22	4.30	26.25	.0001

Table 1 provides summary statistics on steer and heifer weekly live weight prices and grid market share. Grid market share results reported in Table 1 are very similar to Lange's original findings. Weekly live weight prices reported in Table 1 are almost identical for steers and heifers.

Table 2 reports that, on average, the mean live weight price is seven cents higher for heifers (p-value <0.0001) and the range in the differential is less than a dollar. This indicates that our assumption that steer and heifer live weight prices are equivalent is reasonable.[10]

The grid market share differential results, reported in Table 2, indicates that steer grid market share of weekly slaughter volume, on average, is 9.2% higher than heifer market share.

The standard deviation and range are relatively high as compared to the mean. Thus, we decided to report the quantile probability estimates associated with the distribution's CDF for the grid market share differential in Table 3.

Table 3: Quantile Intervals for Grid Market Share Differentials: Steer minus Heifer Market Share

Quantile	Estimate
100% Max	0.245
99%	0.216
95%	0.160
90%	0.143
75% Q3	0.115
50% Median	0.091
25% Q1	0.065
10%	0.037
5%	0.022
1%	0.001
0% Min	-0.017

Table 3 supports the conclusion of the Wilcoxon test results that heifer grid market share is lower than steer grid market share of weekly slaughter volume by a considerable amount. We therefore conclude that there is reasonable statistical evidence to support the hypothesis drawn from Corollary 1. That is, if producers perceive an increase in carcass quality uncertainty, then they will alter their marketing decisions. As a result, fewer producers will market their slaughter animals on a grid and grid market share will decline. Furthermore, a plausible explanation for the grid market share differential between steers and heifers is that producers view grid marketing as a risky pricing alternative for heifers relative to steers. Finally, fluctuations in perceived risk and risk preference provide a credible explanation for fluctuations in the market share of weekly slaughter volume across the three marketing channels for slaughter cattle.

Summary:

We have demonstrated that the "Theory of Factor Price Disparity" proposed by Fausti and Feuz (1995) combined with the assumption of varying degrees of producer risk preference is a plausible explanation for: a) the coexistence of multiple marketing channels (live wt., dressed wt., and grid) for slaughter cattle, b) the grid market share differential between steer and heifer slaughter volume, and c) the variability in market share of slaughter volume across alternative marketing channels for slaughter cattle.

The contribution to the literature goes beyond the extension of the TFPD. We have demonstrated that carcass quality uncertainty and the financial risk associated with it interacts with seller risk preference. This interaction not only sustains the current structure of the slaughter cattle market, but risk and risk preference also influences producer marketing behavior and thus alters marketing patterns. Thus, risk and risk preference are key elements that determine the structure of the slaughter cattle market.

Issues in need of further investigation are: a) the role of alternative marketing arrangements (e.g., Muth et al. 2007, Ward 2009) as a risk reduction tool and how these options (formula and forward contract sales) affect producer marketing decisions, and b) how market power could affect producer marketing decisions.

References:

Anderson, J.D., and K.A. Zeuli. 2001. "The Revenue Risk of Value-Based Pricing for Fed Cattle: A Simulation of Grid vs. Average Pricing." *International Food and Agribusiness Management Review* 4:275-286.

Bishop, G.L., J.R. Brethour, T.T. Marston, and T.E. Lawrence. 2003. "Effects of pregnancy in feedlot heifers on performance and carcass characteristics." In Cattleman's Day. Paper presented at Cattlemen's Day, Kansas State University, Manhattan, KS, March 7. Available at: http://hdl.handle.net/2097/4440.

Chatterjee, K., and L. Samuelson. 1987. "Bargaining with Two-sided Incomplete Information: An Infinite Horizon Model with Alternating Offers." *Review of Economic Studies 54: 175-192.*

Choat, W.T., J.A. Paterson, B.M. Rainery, M.C. King, G.C. Smith, K.E. Belk, and R.J. Lipsey. 2006. "The effect of cattle sex on carcass characteristics and longissimus muscle palatability." *Journal of Animal Science* 84:1820-1826.

Corah, L., and M. McCully. 2006. "Declining Quality Grades: A Review of Factors Reducing Marbling Deposition in Beef Cattle." Certified Angus Beef White Paper. Available at: http://www.cabpartners.com/news/research/declining_quality_grades.pdf.

Faminow, M.D., M. de Matos, and R.J. Richmond. 1996. "Errors in slaughter steer and heifer prices." *Agribusiness* 12(1):79-87.

Fausti, S.W., and D.M. Feuz. 1995. "Production Uncertainty and Factor Price Disparity in the Slaughter Cattle Market: Theory and Evidence." *American Journal of Agricultural Economics* 77:533-540.

Fausti, S.W., D.M. Feuz, and J.J. Wagner. 1998. "Value-based marketing for fed cattle: A discussion of issues*." International Food and Agribusiness Management Review* 1:73-90.

Fausti, S.W., and B.A. Qasmi. 2002. "Does the Producer Have an Incentive to Sell Fed Cattle on a Grid?" *International Food and Agribusiness Management Review* 5:23-39.

Fausti, S., B. Qasmi, and M. Diersen. 2008. “Grid Marketing and Beef Carcass Quality: A Discussion of Issues and Trends.” Dept. Econ. Staff Paper No.2008-3, South Dakota State University, June.

Fausti, S.W., B.A. Qasmi, M.A. Diersen, and J. Li. 2010. “Value Based Marketing: A Discussion of Issues and Trends in the Slaughter Cattle Market.” *Journal of Agribusiness* 28(2):89-110.

Fausti, S.W., B.A. Qasmi, M.A. Diersen, J. Li, and B. Lange. 2011. “The Affect of Animal Gender on Fed Cattle Producer Marketing Behavior.” Paper presented at the SAEA annual meeting, Corpus Christi TX, 5-8 February.

Federal Register. 1997. “*Proposed Rules: Filing of a Petition for Rulemaking: Packer Livestock Procurement Practices*.” 62(9):1847, January 14.

Feuz, D.M., S.W. Fausti, and J.J. Wagner. 1993. "An Analysis of the Efficiency of Four Marketing Methods for Slaughter Cattle." *Agribusiness: An International Journal* 9(5):453-63

___. 1995. "Risk and Market Participant Behavior in the U.S. Slaughter Cattle Market." *Journal of Agricultural and Resource Economics* 20(1):22-31.

Garcia, L.G., K.L. Nicholson, T.W. Hoffman, T.E. Lawrence, D.S. Hale, D.B. Griffin, J.W. Savell, D.L. VanOverbeke, J.B. Morgan, K.E. Belk, T.G., Field, J.A. Scanga, J.D. Tatum, and G.C. Smith. 2008. “National Beef Quality Audit 2005: Survey of targeted cattle and carcass characteristics related to quality, quantity, and value of fed steers and heifers.” *Journal of Animal Science* 86:3533- 3543.

Gujarati, D.N. 2003. *Basic Econometrics*, 4th ed. New York: McGraw-Hill.

Kreikemeier, K.K., and J.A. Unruh. 1993. "Carcass traits and the occurrence of dark cutter in pregnant and non-pregnant feedlot heifers." *Journal of Animal Science* 71:1699-1703.

Lange, B. 2009. "A Comparison of the Steer and Heifer Cattle Slaughter with Respect to Grid Pricing and Marketing Channels." MS thesis, South Dakota State University.

Muth, M.K., J. Del Roccili, M. Asher, J. Atwood, G. Brester, S.C. Cates, M.C. Coglaiti, S.A. Karns, S. Koontz, J. Lawrence, Y. Liu, J. Marsh, B. Martin, J. Schroeter, J.L. Taylor, and C.L. Viator. 2007. "GIPSA Livestock and Meat Marketing Study, Volume 3. Fed Cattle and Beef Industries." Research Triangle Park, NC: U.S. Department of Agriculture, Grain Inspection, Packers and Stockyards Administration, RTI International, January.

Newbold, P. 1995. *Statistics for Business and Economics,* 4th ed. Upper Saddle River, NJ: Prentice-Hall, Inc.

Pratt, J.W. 1964. "Risk aversion in the small and the large*." Econometrica 32*: 122-136.

Robison, L.J., and P.J. Barry. 1987. *The Competitive Firm's Response to Risk.* New York: MacMillan.

Sandmo, A. 1971. "On the Theory of the Competitive Firm Under Price Uncertainty." *American Economic Review* 61:65-73.

Scanga, J.A., K.E. Belk, J.D. Tatum, T. Grandin, and G.C. Smith. 1998. "Factors contributing to the incidence of dark cutting beef." *Journal of Animal Science* 76:2040-2047.

Schlotzhauer, S.D., and R.C. Littell. 1987. *SAS System for Elementary Statistical Analysis*. Cary, NC: SAS Institute, Inc.

Schroeder, T.C., and J.L. Graff. 2000. "Estimated Value of Increased Pricing Accuracy for Fed Cattle*." Review of Agricultural Economics* 22:89-101.

Shultz, R.W., and J.M. Marsh. 1985. "Steer and Heifer Price Differences in the Live Cattle and Carcass Markets." *Western Journal of Agricultural Economics* 10(July):77-92.

Tatum, J.D., S.L. Gruber, and B.A. Schneider. 2007. "Executive Summary, Pre-Harvest Factors Affecting Beef Tenderness in Heifers." Research report prepared for National Cattlemen's Beef Association. January. Available at: http://www.beefresearch.org/CMDocs/BeefResearch/Pre-Harvest%20Factors%20Affecting%20Beef%20Tenderness%20in%20Heifers.pdf .

U. S. Department of Agriculture, Agricultural Marketing Service. (2004, April – 2010, May). "National Weekly Direct Slaughter Cattle-Negotiated Purchases: LM_CT154." USDA/AMS weekly reports: Weekly data was collected online from the Livestock Marketing Information Center's members only website. Available at: http://www.ams.usda.gov/mnreports/lm_ct154.txt.

___. (2004, April – 2010, May). "National Weekly Direct Slaughter Cattle Report – Formulated and Forward Contract: LM_CT151." Weekly data was collected online from the Livestock Marketing Information Center's members only website. Available at: http://www.ams.usda.gov/mnreports/lm_ct151.txt.

___. (2004, April – 2010, May). "USDA-AMS 5-Area Weekly Weighted Average (LM_CT150)." Weekly data was collected online from the Livestock Marketing Information Center's members only website. Available at: http://www.ams.usda.gov/mnreports/lm_ct150.txt.

Voisinet, B.D., T. Grandin, S.F. O'Connor, J.D. Tatum, and M.J. Deesing. 1997. "*Bos indics-cross* feedlot cattle with excitable temperaments have tougher meat and a higher incidence of borderline dark cutters." *Meat Science* 46:367-377.

Ward, C.E. 2009. "Extent of Alternative Marketing Arrangements for Fed Cattle and Hogs." Oklahoma State University Coop Ext Ser AGEC-615.

White, B.J., J.D. Anderson, W.B. McKinley, and J. Parish. 2007. "Factor Price Disparity and Retained Ownership of Feeder Cattle: An Application of Feedlot and Carcass Performance Data to Farm-Level Decision Making." *Journal of Agricultural and Applied Economics* 39:87-101.

Zinn, R.A., A. Barreras, F.N.Owens, and A. Plascencia. 2008. "Performance by feedlot steers and heifers: Daily gain, mature body weight, dry matter intake, and dietary energetic." *Journal of Animal Scienc*e 86:2680-2689.

Footnotes:

[1] In the context of this paper "marketing channel" refers to selling cattle live weight or dressed weight by the pen or selling cattle based on individual carcass characteristics (grid sales). The cattle marketing literature also has a branch the focuses on "alternative marketing arrangements" or AMA (e.g. Muth 2007). This literature addresses issues associated with selling cattle in the cash market versus selling on a contract (forward contracts and formula agreements). The marketing channel issue addressed in this paper focuses on how carcass quality uncertainty affects pricing mechanisms associated with marketing channel selection by producers.

[2] In the Fausti and Feuz analysis, they compare average pen pricing systems to the Grade and Yield carcass pricing system. The Grade and Yield pricing mechanism is the precursor to grid pricing mechanism.

[3] Feuz et al. 1993 discusses how financial risk associated with uncertainty over carcass quality shifts from buyer to seller across marketing alternatives as more information becomes available about carcass quality when sales shift from pen level to individual carcass level transactions.

[4] Fausti et. al. (1998) provides empirical evidence that above (below) average quality cattle receive a premium (discount) when selling on a grid relative to the dressed weight marketing alternative.

[5] We are implicitly assuming that there is zero cost across marketing alternatives and that cost of producing an animal is not influenced by the seller's selection of a marketing alternative.

[6] As the seller becomes less risk-averse, the limit of the risk premium approaches zero: $\lim_{U'' \to 0} (\theta) = 0$. Set S represents a cohort of sellers with varying degrees of risk aversion, thus over the continuum of sellers risk premium requirements vary. Marketing channel decisions are based upon risk premium requirements.

[7] $\theta = \lambda$ indicates the risk premium the packer charges when buying cattle live weight (the seller's certainty alternative price to selling on a grid is reduced by λ) is equal to the risk premium (θ) the producer is willing to pay to avoid selling on a grid.

[8] If packers consider purchasing heifers live a risker activity than purchasing steers live, then λ for heifers will be higher. Therefore, if the live weight price for heifers and steers is assumed equal, then the expected market value of live heifers (P_G) is perceived by packers to be greater than steers. Therefore, our assumption for steer and heifer live weight price ($P_{L\lambda}$) appears to be reasonable. The statistics reported in Tables 1 and 2 support this view.

[9] The assumptions necessary for the reliability of the Wilcoxonian test statistic are: a) the matched pair differences reflect a random variable, and b) the distribution of matched pair differences is symmetric. Table 3 indicates a symmetric distribution.

[10] The equivalence of steer and heifer live weight price suggests the packer's risk premium gender differential when purchasing steers and heifers live weight is negligible. A negligible risk premium differential may be the result of a tradeoff respect to carcass quality gender risk. The tradeoff being the dark cutter and pregnancy risk associated with heifers is offset by heifers having a higher level of carcass quality. The animal science literature suggests that such a tradeoff exists.

FIGURE 1

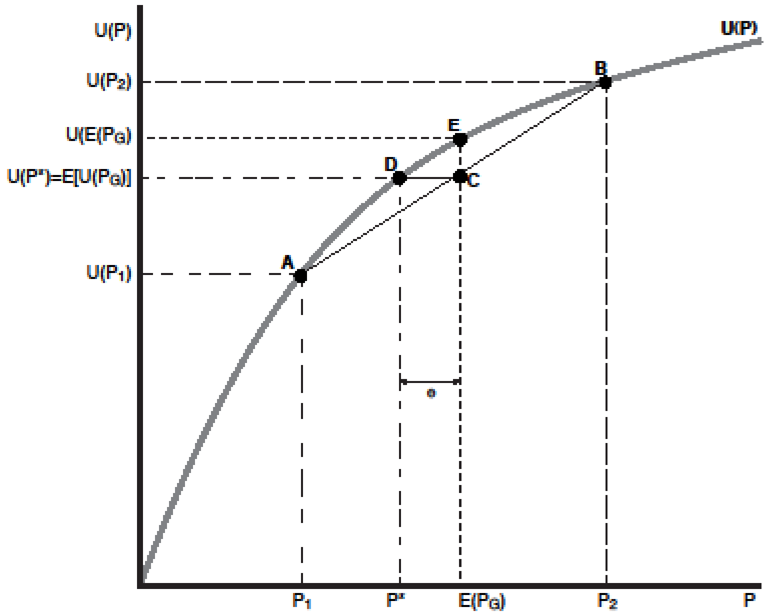


FIGURE 2

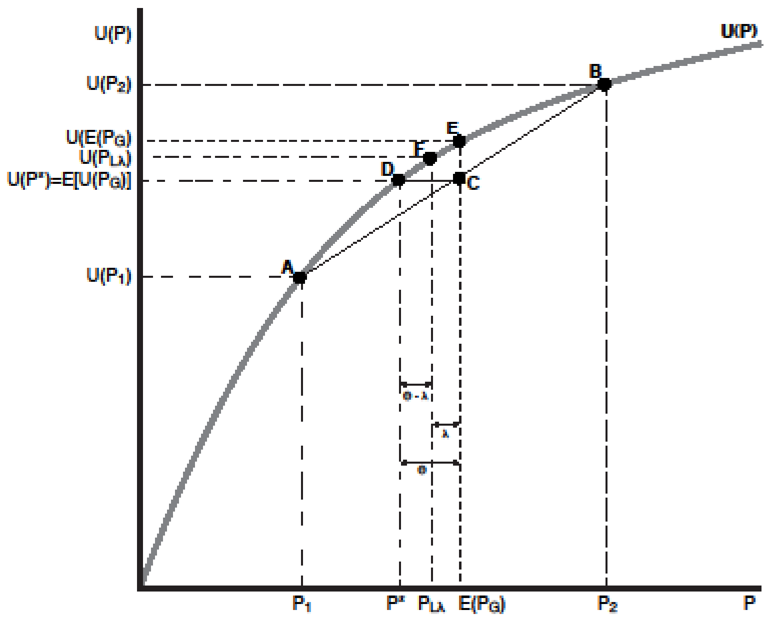
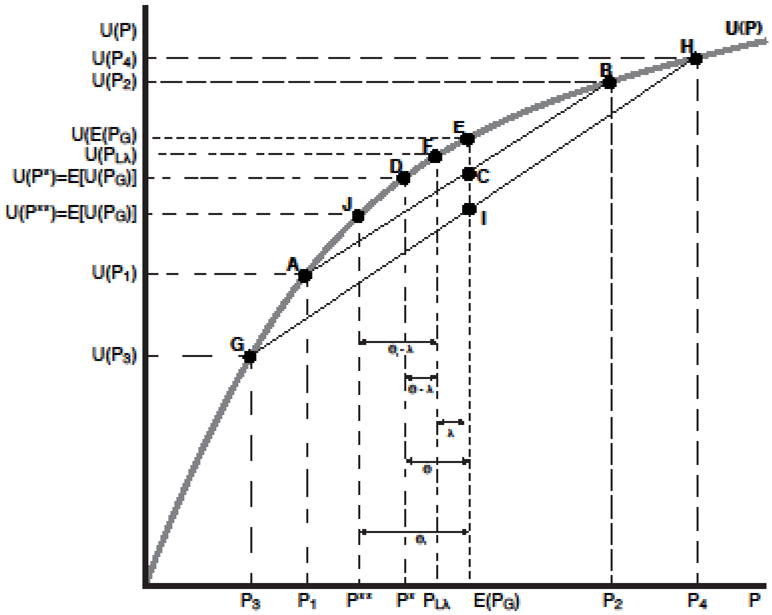


FIGURE 3



U(P)
U(P4)
U(P2)
U(E(PG)
U(PLλ)
U(P*)=E[U(PG)]
U(P**)=E[U(PG)]
U(P1)
U(P3)
U(P)
H
B
E
F
D
C
J
I
A
G
P3
P1
P**
P*
PLλ
E(PG)
P2
P4
P