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Economic Value of a Beef Tenderness-Based Fed Cattle Valuation System

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Executive Summary

- Beef tenderness is one of the most important determinants, together with flavor, of the consumer eating experience. Challenges with managing for beef tenderness have been well documented. However, even a small proportion of tough product in the meat case or foodservice offering adversely impacts beef demand. Consumers dislike products that fail to deliver consistently desirable eating experiences, and consumers reduce demand for beef when they have bad eating experiences. Managing for beef tenderness is a complex and multi-faceted challenge because so many different dimensions of animal genetics, production management, feeding/implant programs, slaughtering activities, further processing, aging, product preparation, and others affect beef product tenderness.

- This study focuses on one component of the complex beef tenderness arena - - developing a meat tenderness valuation system for fed cattle. Development of a tenderness premium and discount schedule for fed cattle will provide increased incentive for producers to adopt animal genetic and production strategies that improve beef tenderness.

- Consumer demand for product characteristics drives value opportunities. Thus, to develop a tenderness valuation system for fed cattle requires first determining what consumers are willing to pay for tender beef. Two different methods are used here to determine what consumers are willing to pay for beef tenderness assurances: 1) review, analysis, and synthesis of literature estimating consumer willingness to pay for beef tenderness, and 2) a sampling of current tenderness premiums on retail beef steaks.

- Past literature shows statistically significant premiums for tender relative to tough steaks, in every study, for every sampling method, and every value elicitation technique. However, the range of estimated premiums is wide from $0.42/lb to more than $5.00/lb. Analysis of past literature, adjusting for variation among the study methods, indicates that the amount a typical consumer is willing to pay for a tender relative to a tough steak is around $1.84/lb. Our own sampling of Strip Loin and Ribeye steak products at selected retail stores revealed a nearly identical current premium of $1.82/lb for *tenderness premium* labeled products.

- A variety of tender assured branded beef products are being produced today using a myriad of production and processing methods, vertical partnerships, and product assurances to provide tender (and other attributes) products. Closely held tenderness assurance technology and production practices, third-party (USDA) verification of process, and money back guarantees (typically double money back) for dissatisfied consumers are common among current tenderness assured or verified beef programs.

- A tenderness-augmented premium and discount schedule was developed to augment, not replace, current fed cattle grid pricing schemes. The tenderness premium/discount equation is (modified from Platter et al., 2005):

  $$\text{Tenderness Premium (\$/cwt)} = 175.21 - 46.1077 \times \text{WBSF},$$

  where, WBSF is Warner-Bratzler Shear Force in kg.

- The tenderness premium equation is applied to 20% of the carcass weight representing the approximate proportion of products for which tenderness value is assigned (predominantly steak product muscles).

- The tenderness premium schedule is equal to zero (the base tenderness) when WBSF=3.8 kg which is close to what the typical fed cattle marketed today would be expected to have as a longissimus muscle WBSF value.

- The tenderness premium schedule is based on a conservative premium for tender relative to tough steaks. Past literature and our retail survey revealed around $1.80/lb premium for tender relative to tough steaks is probable in the retail counter. The tenderness premium schedule is based on a premium of $1.16/lb when going from a WBSF value of 3.40 kg (very tender) to 5.4 kg (very tough) (Platter et al., 2005). As such, the tenderness premium schedule would leave part of the potential retail premium for tender assured steaks in the hands of downstream packers, processors, and retailers or other product branders.

- Applying the tenderness-augmented valuation equation (with 3.8 kg base) to a sample of 3,154 beef carcasses from the Meat Animal Research Center results in a typical price adjustment of $4.98/cwt associated with tenderness to traditional grid valued carcasses. This means, on average, there is about a $5.00/cwt error relative to beef tenderness when we value fed cattle using a grid without consideration for tenderness or toughness of the steaks from the carcass.

- About 25% of upper Choice carcasses would receive at least a $6.00/cwt higher price with tenderness premiums than under traditional grids. Approximately 24% of upper Choice carcasses would receive a $6.00/cwt or or larger discount because of having relatively tough carcasses. Lower Choice carcasses would also have sizeable value adjustments under a tenderness-augmented grid with about 29% earning a $4.00/cwt or more premium and 20% a $4.00/cwt or larger discount relative to traditional grid valued carcasses. Similar reordering of Select carcass valuation would also occur as many Select carcasses produce more tender steaks products than many Choice grade carcasses.

- Industry may prefer to simply try to remove tough carcasses from the product mix. Technologies such as near-infrared spectroscopy that are not invasive might be viable to help accomplish this goal. This might imply a two-step premium/discount schedule for tough or not tough carcasses. The continuous equation could easily be used to develop such a two-step premium/discount schedule. However, much of the value and efficiency associated with a continuous tenderness measurement and value signal to producers to encourage production practices conducive to producing more tender beef would be lost under such a system.

- Tenderness assurance programs are likely to continue to develop and expand, together with other product assurances. Integrity in beef product labeling relative to tenderness is essential to provide the consumer with consistently tender product when that is what consumers anticipate they are getting when they make a beef product purchase. We observed liberal use of the word “tender” on retail beef package labels. Perhaps product brands will sort this out, but an objective and clear beef tenderness assurance process and labeling nomenclature would be less likely to confuse and alienate consumers as well as reduce the number of bad eating experiences associated with tough beef steaks.

Introduction

Numerous researchers across an array of studies and methods have concluded beef tenderness is an important attribute in consumer demand for beef products. Lusk et al. (2001) found that when consumers were provided information regarding steak tenderness together with completing a taste test of the steak, 90% of them preferred a steak known to be tender based on a slice shear-force test relative to a tough steak. Furthermore, 51% were willing to pay an average premium of $1.84/lb for a tender relative to tough steak. Many studies have found similar results (e.g., Boleman et al., 1997; Miller et al., 2001; Lusk and Schroeder, 2006; and Platter et al., 2005). In addition to tenderness, other product quality attributes including flavor and juiciness are also important beef product quality and eating experience attributes (Killinger et al., 2004). Tatum (2008) summarized research demonstrating beef flavor, especially for products derived from the rib and loin, is strongly related to beef marbling. Beef flavor improves linearly as marbling increases (Smith et al., 1980). Marbling degree is the major determinant of beef quality grade for fed steers and heifers. Thus, beef quality grade is a proxy for beef product flavor.

However, in contrast to flavor, beef tenderness is not strongly related to quality grade. That is, many Choice carcasses produce tough steaks and many Select carcasses produce tender steaks. Wheeler et al. (1994) found that shear force as well as sensory panel tenderness and juiciness ratings improved only slightly as marbling increased. Furthermore, marbling explained only 5% of the variation in product palatability across carcasses. Wulf et al. (1997) found a correlation of only -0.12 between marbling and shear force value and the correlation between marbling and consumer panel tenderness ratings of beef products was only 0.11 whereas they found a correlation between shear force and consumer rated tenderness of -0.76 (lower shear force value had greater tenderness ranking).[1]

Collectively, past research demonstrates that beef product tenderness, especially for products from the Loin and Rib, is important to consumer satisfaction and consumers demonstrate willingness to pay for tender relative to tough beef. However, current beef quality grading standards are poor predictors of beef product tenderness. Cattle producers are paid for fed cattle based in part upon quality grade (actual or estimated). Using USDA quality grades to assess carcass values results in over-valuing some carcasses and under-valuing others relative to tenderness valuation. This study determines the dollar magnitude of fed cattle valuation error associated with grid pricing that relies solely on quality grades and does not use an objective direct measure of beef tenderness in the price determination. We also develop a tenderness-

[1] Correlation ranges between -1 and 1 with a -1 correlation indicating two observed data series react exactly opposite to each other, a 0 correlation indicating two observed data series do not react to each other, and a 1 correlation indicating two data series move exactly together.

based fed cattle valuation system to demonstrate the potential improvement in cattle valuation that could be obtained through valuing carcasses including tenderness values in the pricing mechanism. This information is essential in development of a new fed cattle valuation method that builds on the current grid structure with emphasis on valuing carcasses based upon tenderness to augment USDA quality grades.

Development of a tenderness-based enhancement to fed cattle pricing grid requires first determining appropriate carcass premiums for beef tenderness and discounts for beef toughness. We complete a review of the literature on consumer willingness to pay for tender relative to tough steaks to illustrate the importance of steak tenderness in consumer demand for beef and to ultimately justify our selected tenderness premium and discount structure selected. We also conduct a brief overview of current beef tenderness programs in place at retail and complete a small hedonic study of retail beef price determinants to assess whether current tenderness assured beef is realizing premium retail prices compared to conventional beef products. Finally, we develop a grid pricing system that augments current grids with a tenderness price factor that could be used to value beef tenderness attributes and we illustrate a new grid system using a large data base of actual carcasses obtained from the Meat Animal Research Center.

Objectives

1. To determine how current pricing systems where meat tenderness levels are not directly part of the valuation technique would differ if objective measures of meat tenderness were incorporated into valuation. This includes an assessment of how fed cattle values would change if meat tenderness levels were incorporated together with USDA quality and yield grades in the valuation method.

2. Design augmented alternative grid pricing/valuation systems for fed cattle that explicitly incorporate meat tenderness value components into the price grid.

3. Demonstrate how tenderness-augmented valuation systems would value fed cattle more consistently with meat quality relative to current price grids.

Valuing Beef Tenderness

Consumers clearly demonstrate preference for tender relative to tough beef steaks. This result has been demonstrated in numerous consumer sensory studies as well as studies soliciting consumer marginal willingness to pay for tender beef. It is well established that consumers can distinguish among different levels of beef tenderness and that they reveal preferences for tender relative to intermediate and tough beef (Boleman et al., 1997).[2] Shackelford et al. (1999) determined that Warner-Bratzler shear force (WBSF) levels of 4.6 kg would have a 50% chance, and 3.9 kg a 68% chance, of being rated as acceptable tenderness by consumers. Platter et al. (2003) concluded the probability that 50% of consumers would find a steak acceptable for tenderness with a WBSF of 4.4 kg and 68% of consumers would find a steak acceptable with a WBSF of 3.7 kg. Huffman et al. (1996) determined that a WBSF level of 4.1 kg was sufficient to ensure a 98% customer satisfaction level in loin steaks. Of interest in developing a pricing system that might pay producers for differing levels of beef tenderness is the value consumers place on tenderness.

Willingness to Pay Research

The most direct way to determine what consumers want in a food product is to measure the economic value they associate with a product possessing specific attributes. Lancaster (1966) is generally credited with developing the foundation theory that consumers generate utility from the characteristics that are bundled together to comprise a good. When consumers purchase

[2] Boleman et al. defined tender as WBSF 2.27-3.58 kg, intermediate as WBSF 4.08-5.40 kg and tough as WBSF 5.90-7.21.

and consume a beef steak, they gain utility from the bundled set of attributes the steak delivers.[3] Consumers select products to purchase based upon the number and level of characteristics per dollar that the product delivers. Many beef product characteristics cannot necessarily be determined at the point of purchase. For example, when purchasing a generic and unlabeled beef steak at the retail counter, consumers do not know the juiciness, flavor, or tenderness of the specific steak. Product attributes the consumer must consume to know are referred to as *experience* attributes. Since the consumer must consume the product in order to know the quality of the eating experience, it is essential for maintaining consumer demand that each eating experience deliver what the consumer desires for each attribute that they care about. A bad eating experience, such as having a tough steak, reduces the consumer's demand and, thus, value for that product. The more consumers care about a specific food product attribute, and the less certainty or ability they have to verify it prior to purchase, the more they will be willing to pay to assure that attribute is present. Product attributes that do not matter to consumers and do not increase their utility when the product is consumed will have low marginal value.

Numerous studies have estimated consumer willingness to pay for tender beef steak attributes. To determine what tenderness is worth, we summarize past research eliciting consumer valuation of beef tenderness. We identified 12 studies that have specifically estimated how much consumers are willing to pay for tender beef steaks. Numerous challenges arise when trying to synthesize and compare results from past research estimating consumer willingness to pay for steak products including:

1. Defining tenderness and the type of product assurance is not consistent across prior studies. Some studies ask the consumer what premium they would be willing to pay for a "Guaranteed Tender" steak relative to one that was not guaranteed. Variations in defining tenderness are used, and some studies use actual shear force measures and determine how much consumers are willing to pay for steaks having different shear force values. For the purpose of summarizing results across studies, we attempted to make the premium estimates we collected from each study to be the amount a consumer would pay for a *tender assured steak* relative to a *tough steak*. We likely have errors in how we calibrated the magnitudes of premiums we compare.

2. Some studies report a single estimate for the premium consumers are willing to pay for tender steaks. However, several studies conducted various experiments and/or used a variety of different valuation elicitation methods and different consumer groups and report numerous premiums across different study stratifications. We used each tenderness premium reported in each study as an observation in our analysis, except where noted otherwise.

3. Calculating a tenderness premium that can be compared across studies is challenging. Some studies estimate and report average premiums for definitive tough or tender steak whereas others report the percentage of consumers willing to pay a certain amount. For example, Shackelford et al. (2001) report the percentage of consumers "definitely", "probably", "probably not", and "definitely not" willing to pay $1.10/kg ($0.50/lb) more to purchase a low slice shear force steak. We assign this a premium of $0.50/lb for the average consumer as about 50% indicate they would "definitely" or "probably" pay this amount. In summary, we had to use judgment that ultimately results in errors

[3] Utility represents the level of satisfaction or dissatisfaction an individual realizes, or expects to realize, from consuming a good. Satisfaction adds to utility and dissatisfaction reduces utility. In referring to components that add to or subtract from overall utility, the term "characteristic" is used to describe product components. The level of the characteristic present determines the level of utility observed. Examples of beef product characteristics included juiciness, flavor, and tenderness.

in willingness to pay premium estimates in our summaries.

4. Some studies use actual steaks and real money with product and money exchange potentially binding. Other studies are hypothetical and use survey questions to estimate willingness to pay. Hypothetical estimates have been generally accepted as biased upward relative to what consumers are actually willing to pay for something compared to when the choice is binding.

5. Some studies have a consumer focusing on just tenderness attributes and inform the consumer of this. The more attributes included in the label of such products can affect the consumers willingness to pay for a trait like tenderness. Gao and Schroeder (2007) determined that what else is included on a product label in addition to tenderness, affects the premium consumers place on tenderness. For example, a cue attribute, like country of origin, might embed things in consumers' minds that are not independent of tenderness and other steak quality perceptions.

6. Studies differ in what they tell the consumer about the product. Some do not tell taste panel consumers that sampled steaks differ in tenderness levels. Taste panel consumers then reveal their preferences for steaks with different tenderness levels that they have to determine through sensory tests. Research by Lusk et al. (2001) determined that if you tell the consumer that one steak is more tender than the other, even with a taste test, real product and money exchange occurring, consumer bias occurs..

7. Different samples of the population comprised of consumers having different preferences affect results.. Past studies Willingness to pay for tender steak studies vary widely in characteristics comprising their samples.

8. Perhaps most important to note in our synthesis of consumer willingness to pay for tender steaks is that the distributions of consumer preferences for tender steaks within studies across consumers is not captured in our comparison of averages across studies. This is important because a product such as an assured or guaranteed tender steak will have different values to different consumers. Furthermore, cost of assuring tenderness levels will increase with the level of assurance and the level of tenderness. Therefore, the profit maximizing amount to invest in making beef more tender, and in the proportion of steaks to label and assure tenderness, cannot be judged from the average willingness of consumers to pay for tender beef. To determine the profit maximizing investment in these activities requires knowing the demand schedule for tenderness (how much will be demanded at each price and tenderness level) not just the average consumer willingness to pay for tender assurances.

Some of the issues in comparing across studies we can try to adjust for by comparing adjusted means of willingness to pay or by regressing willingness to pay estimates on factors associated with the study. Segregating the data across different study attributes together with regression analysis are used to summarize how study protocol affects willingness to pay premium estimates for tender beef steaks.[4]

We identified 12 studies reporting a total of 29 different premium estimates for tender steaks. The studies reviewed together with our characterizations of the study protocols are listed

[4] Regression refers to a method used to simultaneously determine multiple correlations between one specific variable of interest and many other variables that are expected to explain the movement in the variable of interest. The value of regression is that the interaction between explanatory variables is factored into the correlation between a single explanatory variable and the movement in the variable being explained.

in table 1. The single most important finding revealed from reviewing results of the studies is that across all 29 different estimates provided in the 12 studies, consumers are *on average* willing to pay statistically significant premiums for tender relative to tough beef steak. This is a very robust result revealing that the typical consumer values beef steak tenderness. The premiums for tender steaks range from $0.42/lb to $7.35/lb across the 29 estimates.

Six of the 29 observed tenderness premiums involved sensory of consumers actually tasting the product and then revealing their willingness to pay premium. Five of the 29 observations did not reveal a tenderness statement about the steaks to the consumer in the experiment; instead they let the consumer make that determination. Lusk et al. (2001) determined that telling the consumer that a product was tender increased the premium they were willing to pay from $1.23/lb to $1.84/lb on average. Thus, there is an increase in consumer valuation when consumers are informed about the tenderness attribute being present in a steak product. Of the 29 observed premiums, 13 are from non-hypothetical experiments involving real product and actual money exchange by the consumer. The 16 hypothetical experiments were all conducted using choice experiment protocols (though a few choice experiments were non-hypothetic). Choice experiments are situations where the consumer is faced with two or more alternative steaks possessing different attributes and the consumer is asked to pick which they prefer. Repeating the experiments numerous times with varying prices and varying attribute levels enables one to estimate the price premiums and discounts consumers are willing to pay for attributes included in the study.[5]

The 12 studies vary considerably in the sample population and sample size used, partly dictated by the methodology. Generally, non-hypothetical studies have smaller numbers of participants. Often in binding trials the experimental participants are paid for their time making these relatively expensive studies to complete per participant.

[5] An example of a choice experiment is (taken from Lusk and Schroeder, 2006):

Scenario 11	Steaks					
	Generic	Guaranteed Tender	Natural	USDA Choice	Certified Angus Beef	None of These
	$6.75	$7.88	$9.00	$5.63	$7.88	
	⇩	⇩	⇩	⇩	⇩	⇩
I would choose . . .	☐	☐	☐	☐	☐	☐

Table 1. Previous Studies Determining Consumer Willingness to Pay Premiums for Tender Steaks

Authors (Year)	Premium ($/lb)[a]	Tenderness Sensory[b]	Tenderness Revealed[c]	Hypothetic[d]	Choice Exper.[e]	Attributes Evaluated	Partic-ipants	Location
Platter et al. (2005)	0.95	1	0	0	0	2	489	Denver Metro
Miller et al. (2001)	0.42	1	0	0	0	1	734	U.S.
Feuz et al. (2004)	0.48	1	0	0	0	4	273	Denver & Chicago
Feldkamp et al. (2005)	0.95	0	1	0	0	4	55	Manhattan, KS
Lusk & Fox (2000)	3.39	0	1	1	1	5	514	U.S.
Loureiro & Umberger (2004)	1.14	0	1	1	1	5	2319	U.S.
Tonsor et al. (2007)	3.11	0	1	1	1	4	1009	U.S.
Lusk et al. (2001)	1.23	1	0	0	0	1	227	Midwest U.S.
	1.84	1	1	0	0	1	86	Midwest U.S.
Gao & Schroeder (2007)	5.87	0	1	1	1	2	74	Chicago
	5.57	0	1	1	1	3	150	Chicago
	7.35	0	1	1	1	4	76	Chicago
	2.84	0	1	1	1	2	78	Chicago
	3.00	0	1	1	1	3	160	Chicago
	4.56	0	1	1	1	4	82	Chicago
	2.23	0	1	1	1	2	211	K-State
	2.03	0	1	1	1	3	398	K-State
	1.97	0	1	1	1	4	187	K-State
	1.25	0	1	1	1	2	198	K-State
	1.56	0	1	1	1	3	369	K-State
	2.21	0	1	1	1	4	171	K-State
Lusk & Schroeder (2006)	0.80	0	1	0	0	4	35	Manhattan, KS
	5.55	0	1	0	1	4	67	Manhattan, KS
	1.08	0	1	0	0	4	35	Manhattan, KS
	1.09	0	1	0	0	4	22	Manhattan, KS
	0.99	0	1	0	0	4	27	Manhattan, KS
Lusk & Schroeder (2004)	3.85	0	1	0	1	4	67	Manhattan, KS
	4.13	0	1	1	1	4	37	Manhattan, KS
Shackelford et al. (2001)	0.50	1	0	0	0	1	759	Denver

[a] Premiums were converted as best we could do to an estimated $/lb comparison between tender and tough steaks.

[b] Sensory is equal to 1 if the consumer in the study used sensory to assess tenderness vs. not tasting actual product.

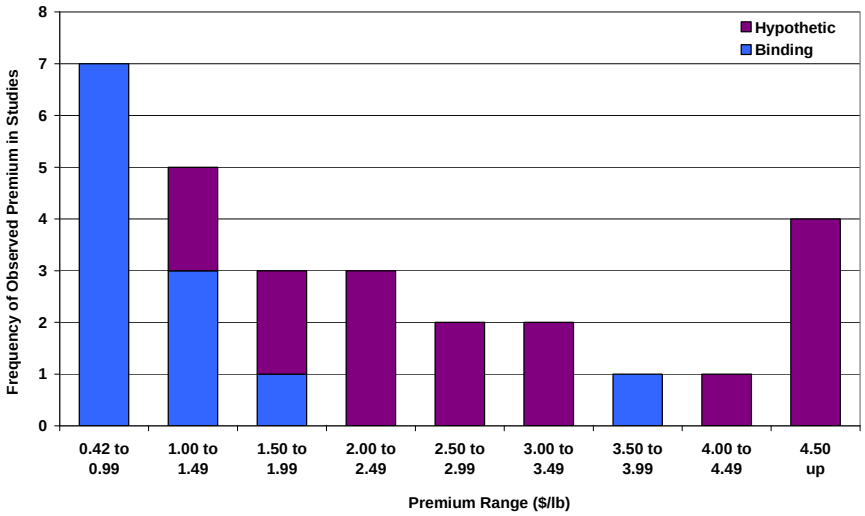
[c] Tenderness Revealed is 1 if the consumer was told which product was tender vs. being blind taste test.

[d] Hypothetic is equal to 1 if the experiment was purely hypothetical without exchange of money for steak by consumer.

[e] Choice Experiment is 1 if the premium was determined using a Choice Experiment method.

The magnitude of average premium consumers are willing to pay for tender steaks varies considerably across estimates. In review of results of these studies, it is apparent that estimates from hypothetical surveys, where the consumer is not bound to pay the price premium they reveal for tender steak, are considerably greater than when the experiment is binding (i.e., actual exchange of money for steak occurs). Figure 1 illustrates the distributions of price premiums from the studies differentiating between hypothetical and binding experimental protocols. The average premium for tender steak in binding studies is $1.52/lb compared to $3.26/lb for hypothetic studies (these averages are statistically different from each other at the 0.01 level).

Figure 1. Distribution Previous Reserach Estimates of Consumer Willingness to Pay Premiums for Tender vs. Tough Beef Steaks, Hypothetical vs. Binding



To further investigate determinants of premiums consumers are willing to pay for tender steaks, regression analysis explaining factors affecting the estimated premiums from prior studies was undertaken. Because of the stark differences in hypothetical vs. binding study willingness to pay estimates, the regression analysis was completed using only the 13 binding willingness to pay estimates (the hypothetical bias can be gleaned directly from the $1.74/lb difference in average premiums for binding vs. hypothetical). We were most interested in explaining factors affecting binding estimates as opposed to hypothetic estimates. The regression model used to summarize factors impacting the tenderness premiums found in past binding studies was:

$$\textit{Tenderness Premium} = \beta_0 + \beta_1 \textit{ Choice Experiment} + \beta_2 \textit{ Sensory} + \beta_3 \textit{ Revealed Tenderness} + e$$

where:
Tenderness Premium is the estimated premium for tender relative to tough steak ($/lb)

Choice Experiment is a dummy variable equal to 1 if the method used was a Choice Experiment and 0 otherwise,

Sensory is a dummy variable equal to 1 if the study included sensory when the consumer revealed willingness to pay and 0 otherwise,

Revealed Tenderness is a dummy variable equal to 1 if the study revealed to the consumer which steak was more tender when they solicited their willingness to pay,

e is a random error, which captures the difference between the actual and estimated tenderness premium for each observation.

The regression model above simultaneously determines the variation in tenderness premium that is associated with use of a choice experiment, use of sensory information in the study, and whether tenderness was revealed to taste panel consumers. For example, an estimated coefficient of 0.25 for the *Revealed Tenderness* variable would indicate that when tenderness was revealed to participants in a study the *Tenderness Premium* increased by $0.25/lb after accounting for whether a *Choice Experiment* was used or not and whether the study had *Sensory* or not.

From casual observation, it appears that *Choice Experiments* result in larger premium estimates than other solicitation methods. This is a

bit disconcerting and we are not certain why this is the case. However, we include this impact in the models to determine whether it is true. *Sensory* is included because we anticipate that if a consumer tests the product, they will have greater trust in the tenderness level of the steak and be willing to pay more for it. Whether the study reveals to the consumer that a steak is tender is expected to positively impact willingness to pay based on work by Lusk et al. (2001). Thus, we expect a positive sign on *Revealed Tenderness*. We also tested whether the number of attributes included in the study affected the tenderness premium and it was not statistically significant so it was not included. We hypothesize the type of additional attributes included in a study might be more important than the number and with sensory we have little way to measure or control for these in this review.

Results of the regression analysis are provided in table 2. The regression explains 93% of the variability in willingness to pay premiums for non-hypothetical estimates from previous research. Among these studies, *Choice Experiments* result in $3.72/lb greater willingness to pay estimates than other protocols. We are not able to assess the viability of choice experiments relative to other methods in this study as that is well beyond the scope of our purpose. However, use of this method has resulted in much larger premiums for tenderness assurances for steaks than other methods and this deserves future consideration in such studies. We have a small number of observations represented by non-hypothetical choice experiment results in our sample (only 2 such observations) so we cannot generalize from this finding with any confidence.

Whether the consumer tastes the steak (*Sensory*) results in a $0.86/lb greater premium (marginally statistically significant at $p = 0.13$ level with a two-tailed test) relative to if they do not taste the steak. Consumers are willing to pay more when they know from experience that the product is tender. If the consumer is told that a steak is tender (*Revealed Tenderness)* they are willing to pay $1.12/lb more for that steak than if they are not told. This suggests steak labeling with tenderness assurances are likely to garner premium prices for the typical consumer relative to not providing the information on the label. The predicted price premium for *Sensory*=1 and *Revealed*=1 is (*Choice Experiment*=0):

Predicted Premium ($/lb) = -0.142 + 0.858 + 1.124 = $1.84/lb.

This would represent a premium consumers would be willing to pay for a branded product which is labeled as tender assured and from experience they determine the product offers a consistent tender eating experience. However, typical consumers would likely not pay this much initially for an untested product, so a premium of $1.12/lb may be more attainable at least initially.

Table 2. Regression Estimates Summarizing Factors Affecting Willingness to Pay Premiums from Binding Steak Tenderness Studies

Variable	Parameter Estimate	Standard Error	p-value
Intercept	-0.142	0.559	0.805
Choice Experiment	3.718	0.395	<.0001
Sensory	0.858	0.518	0.132
Revealed Tenderness	1.124	0.518	0.058
R-Squared	0.93		
RMSE	0.47		
Observations	13		

Does Labeled "Tender" Mean a Higher Retail Price?

One aspect of interest is what product premiums are for tender assured beef products in the retail counter. We are not aware of any study that has collected retail beef steak prices specifically to determine whether the term "tender" on the label is associated with a higher steak price after adjusting for other relevant factors. To determine whether retail steak prices are differentiated when they contain the word "tender" on the label, we collected a snap-shot of ribeye and strip loin steak prices at a point in time across selected retail stores located in Colorado, Kansas, and Nebraska.

Several caveats and limitations of these analyses are important to establish at the outset. First, a variety of stores were sampled including from large national grocers to small local stores, but no effort was made to get a representative sample of all types of stores in the region that sell retail beef products. Second, having stores located only in Colorado, Kansas, and Nebraska (and selected locations in those states), our sample has a limited geographic scope and does not represent a national perspective. Third, our sample was collected at one point in time during late March and early April 2008 and as such is a snapshot of just that point in time.

Retail Price Data

Prices for ribeye and strip loin steaks were collected from selected retail grocery stores located in Colorado, Kansas, and Nebraska during March-April 2008. A total of 20 different retail outlets were visited (some being the same chain in different locations), and prices and associated product label characteristics were collected for 112 ribeye and strip loin steak packages. Summary statistics of the data collected are presented in table 3. Variable definitions are:

Steak Price is the retail package labeled steak price (excluding store card holder discounts if any apply) ($/lb)

Deli Case is a binary variable equal to 1 if the steak was located in the deli and 0 if it was prepackaged (foam tray) and in the meat case

National Brand is a binary variable equal to 1 if the steak had a national brand on the package and equal 0 otherwise

Store Brand is a binary variable equal to 1 if the steak had a store brand on the package label and equal 0 otherwise

Angus is a binary variable equal to 1 if the steak had the name "Angus" on the package label and equal 0 otherwise

Choice is a binary variable equal to 1 if the steak had "Choice" on the package label and equal 0 otherwise

Select is a binary variable equal to 1 if the steak had "Select" on the package label and equal 0 otherwise

Natural is a binary variable equal to 1 if the steak had "Natural" on the package label and equal 0 otherwise

Tender is a binary variable equal to 1 if the steak had "Tender" on the package label and equal 0 otherwise

TenderPrem is a binary variable equal to 1 if the steak was a "Tender Premium" product and equal 0 otherwise

Boneless is a binary variable equal to 1 if the steak was boneless and equal 0 otherwise

Strip Loin is a binary variable equal to 1 if the steak was a strip loin and equal 0 if it was a ribeye

Weight is the weight of the package label (lbs), if the steak was in the deli, weight was assumed to be 1 lb.

Number is the number of steaks in the package

*Denver i*s a binary variable equal to 1 if the store was located in the Denver area and equal 0 otherwise

CO Mtn is a binary variable equal to 1 if the store was located in the Colorado Mountain region (included Vail and Avon) and equal 0 otherwise

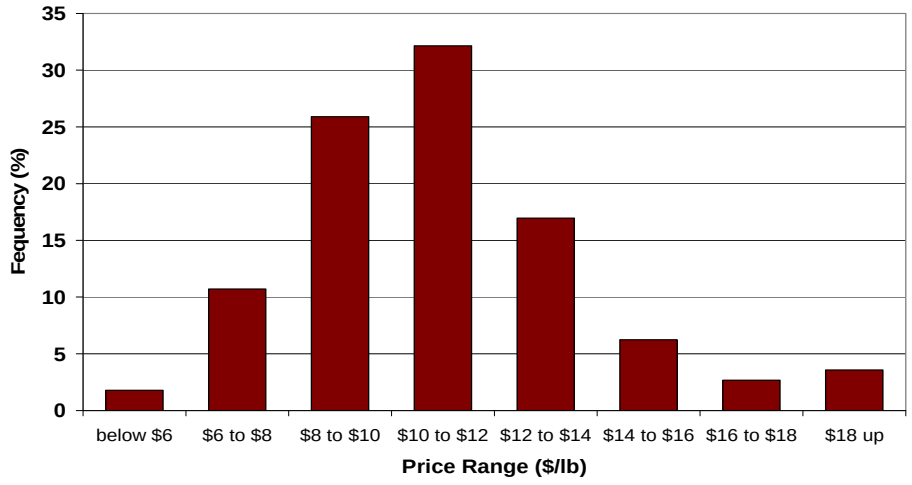
KS is a binary variable equal to 1 if the store was located in Kansas (included Hays, Manhattan, Leawood, Lawrence, Overland Park, and Shawnee) and equal 0 otherwise

NE is a binary variable equal to 1 if the store was located in Nebraska (included Lincoln) and equal 0 otherwise

The average steak price was $11.39/lb with a range from $4.99/lb to $19.99/lb. Retail steak products are sold either packaged in the meat case or in a deli setting where customers select specific unpackaged steaks. In our sample, 25% of the steaks were from the deli case and the remaining 75% were prepackaged in the meat case. Product labels can include a national brand (e.g., Certified Angus Beef), a store brand (e.g., Rancher's Reserve - a Safeway brand), both store and national brands as a co-branded product, or neither brand. Our sample had 22% of products with *only* a national brand (42% with a national brand and/or national plus store brand), 48% with *only* a store brand (68% with a store and/or store plus national brand), 20% with both a store and national brand, and 11% with neither a store nor national brand. Of the 112 steaks, 30% had the name "Angus" on the label, 47% indicated "Choice" product, and 7% were labeled "Select".

One-third of the steaks had "Natural" on the label and 41% had the term "Tender" on the label. The term "Tender" on the label was used in widely different ways, from a simple statement on the package of "Tender" to verified or increased tenderness assurances. Because of the wide range of tender labeling (more discussion on implications of this later), we also identified products that were premium product lines that had specifications to presumably increase tenderness likelihood including "dry aged", "Choice", "Certified", and related claims supporting a tenderness assurance. The premium tender products were categorized separately as *TenderPrem* and represented 38% of all steaks. The vast majority of the steaks (92%) were boneless and 47% of our sample was strip loins and the remaining 53% ribeyes. Package weight ranged from about one-half pound to more than 4 pounds coinciding with single to multiple steaks per package. We assumed all deli steaks were one per package and weighed one pound.

Figure 2. Distrbution of Ribeye and Strip Loin Steak Prices



A frequency distribution of prices is provided in figure 2. Most steaks (75%) in our sample had prices between $8 and $14 per lb. There were 7 steaks of the 112 in our sample with prices of $16 or more per lb. Clearly, a wide range of ribeye and strip loin steak prices are present in retail counters.

Table 3. Summary Statistics of Retail Ribeye and Strip Loin Steaks (N=112)

Variable (units)	Mean	Std. Dev.	Min.	Max.
Steak Price ($/lb)	11.39	2.92	4.99	19.99
Deli Case (0,1)	0.25	0.43	0	1
Brand and/or Quality Grade on Label				
National Brand (0,1)	0.42	0.50	0	1
Store Brand (0,1)	0.68	0.47	0	1
Angus (0,1)	0.30	0.46	0	1
Choice (0,1)	0.47	0.50	0	1
Select (0,1)	0.07	0.26	0	1
Product Additional Label Attributes				
Natural (0,1)	0.33	0.47	0	1
Tender (0,1)	0.41	0.49	0	1
TenderPrem (0,1)	0.38	0.49	0	1
Boneless (0,1)	0.92	0.27	0	1
Strip Loin (0,1)	0.47	0.50	0	1
Weight (lbs)	1.04	0.53	0.46	4.23
Number	1.19	0.71	1	4
Store Location				
Denver (0,1)	0.10	0.30	0	1
CO Mtn. (0,1)	0.14	0.34	0	1
KS (0,1)	0.62	0.49	0	1
NE (0,1)	0.14	0.35	0	1

One relatively recent development in retail grocery beef steak offerings is deli case product. Many retail grocers have added a deli steak product in addition to the pre-packaged meat case offering. Often, the deli steak offering has some special feature such as a natural product label and/or some other premium brand segmented market. A comparison of the deli steak versus the more traditional meat case pre-packaged product, summary statistics of steak prices and characteristics were calculated for the two different product displays (table 4). The average price of the deli case steak was $13.87/lb compared to $10.55/lb for prepackaged meat case product. The deli case product was typically Choice (79%) and had a store brand (89%). The presence of natural product was twice as likely in the deli (54%) compared to the meat case (26%).

Table 4. Summary Statistics Comparing Deli Case and Meat Case Retail Ribeye and Strip Loin Steaks

	Deli Case (N=28)		Meat Case (N=84)	
Variable (units)	Mean	Std. Dev.	Mean	Std. Dev.
Steak Price ($/lb.)	13.87	3.35	10.55	2.23
Deli Case (0,1)	1	0	0	0
Brand and/or Quality Grade on Label				
National Brand (0,1)	0.36	0.49	0.44	0.50
Store Brand (0,1)	0.89	0.32	0.61	0.49
Angus (0,1)	0.32	0.48	0.30	0.46
Choice (0,1)	0.79	0.42	0.37	0.49
Select (0,1)	0.04	0.19	0.08	0.28
Product Additional Label Attributes				
Natural (0,1)	0.54	0.51	0.26	0.45
Tender (0,1)	0.36	0.49	0.43	0.49
TenderPrem (0,1)	0.68	0.48	0.26	0.45
Boneless (0,1)	0.86	0.36	0.94	0.24
Strip Loin (0,1)	0.46	0.51	0.48	0.50
Weight (lbs)	1.00	0.00	1.05	0.61
Number	1	0	1.26	0.81
Store Location				
Denver (0,1)	0.04	0.19	0.12	0.33
CO Mtn. (0,1)	0.07	0.26	0.16	0.37
KS (0,1)	0.57	0.50	0.63	0.48
NE (0,1)	0.32	0.48	0.09	0.28

Price Determinant Approach and Results

To quantify steak price determinants from our retail price survey, we estimated the following regression model of factors related to price:

$$Steak\text{Price} = \beta_0 + \beta_1 DeliCase + \beta_2 NationalBrand + \beta_3 StoreBrand + \beta_4 Angus + \beta_5 Choice + \beta_6 Select + \beta_7 Natural + \beta_8 Tender + \beta_9 TenderPrem + \beta_{10} StripLoin + \beta_{11} Boneless + \beta_{12} Weight + \beta_{13} COMtn + \beta_{14} KS + \beta_{15} NE + \beta_{16} LowEndStore + e$$

All variables are as defined earlier (e is an error term) with the addition of *LowEndStore,* a binary variable equal to 1 for one particular store we collected prices for four steaks from that had steak prices that were substantially lower than other stores in our sample with no apparent reason other than the store being located in a low-income area. The regression results were not sensitive to keeping the four low-priced steaks with the dummy variable for that store included or dropping those observations from the model. Thus, they were retained. Results were sensitive to keeping the four low-priced steaks in the model and not putting in the store dummy variable.

Table 5. Regression Estimates of Ribeye and Strip Loin Steak Prices

Variable	Coefficient Estimate	Standard Error	p-value
Intercept	9.31	1.83	0.00
Deli Case (0,1)	1.24	0.60	0.04
Brand and/or Quality Grade on Label			
National Brand (0,1)	1.30	0.80	0.11
Store Brand (0,1)	0.31	0.69	0.66
Angus (0,1)	-0.19	0.62	0.76
Choice (0,1)	0.38	0.69	0.59
Select (0,1)	1.70	1.40	0.23
Product Additional Label Attributes			
Natural (0,1)	1.49	0.67	0.03
Tender (0,1)	0.16	0.77	0.83
TenderPrem (0,1)	1.82	0.86	0.04
Strip Loin (0,1)	-1.76	0.33	0.00
Boneless (0,1)	1.16	0.93	0.21
Weight (lbs)	-0.26	0.48	0.58
Store Location (Default=Denver)			
CO Mtn. (0,1)	1.70	1.29	0.19
KS (0,1)	-1.05	1.11	0.35
NE (0,1)	0.83	1.15	0.47
Low-End Store (0,1)	-5.69	2.08	0.01
R-Squared	0.53		
RMSE	2.29		
Observations	112		

Of particular interest for this study is the price impact of the *Tender* and *TenderPrem* labels on the steak package. One test of whether steak tenderness has value is to assess whether steaks having the word "tender" on the package label increases the steak price holding other product characteristics constant.

Regression results are reported in table 5. The regression model explained 53% of steak price variability. There is a lot of variation in prices across steaks related to factors not included in the model.

Products that are sold from the deli case are priced at $1.24/lb higher than prepackaged meat case products, after adjusting for other attributes. Dutton et al. (2007) found custom cut steaks to have a $0.37/lb premium relative to pre-packaged foam tray steaks, so our result has much higher prices for these products. Part of the deli premium found in our data may well be related to higher product quality standards present in the steaks we found present in deli settings as was summarized in table 4.

National product brands had a premium price of $1.30/lb which was marginally statistically significant ($p=0.11$). Store brand did not have higher prices associated with it relative to non-branded steaks. Similarly, having the term "Angus" on the package was not associated with a statistically significant premium. Parcell and Schroeder (2007) found similar results to ours with branded high quality steak products having a $1.22/lb premium relative to unbranded product. Our sample only has 12 steaks that contained no brand and these steaks were all from the same chain, though from stores located in two different states. Dutton et al. (2007) found substantial premiums of $5.87/lb for what they categorized as "Special" branded beef steaks containing "all natural, organic, no antibiotics, etc." on the label. Most of these steaks in their study were found in specialty types of stores that target store sales to particular consumer segments (e.g., Wild Oats). We include separate variables for "natural" and therefore we should capture some of the premiums for that type of product in that variable.

Choice and Select graded products did not have premiums relative to product that did not contain the quality grade designation on the label. Very important to keep in mind though is that nearly every Choice labeled product on the retail shelf has additional branding and other product performance label claims that may be related to the quality grade, so this result needs to be conditioned keeping that in mind. Parcell and Schroeder (2007) and Dutton et al. (2007) also did not find statistically significant premiums for Choice labeled products.

Natural steaks were priced $1.49/lb greater than steaks that did not have "natural" on the label. We did not have sufficient steaks in our sample to determine whether naturally raised or minimally processed were the primary drivers of the natural price premium. Dutton et al. (2007) found a premium of $0.25/lb for "all natural" beef, but part of the natural premium for steaks in their study was partially reflected in their "Special" product category premium mentioned earlier.

The premium for having "tender" on the label was not statistically different from zero. However, the tender premium product had a $1.82/lb higher price than product not carrying that designation ($p<0.05$). Our study is the first to examine this specific tenderness labeling attribute as far as we are aware, so we do not have other studies to compare our results here to. However, for the steaks in our sample, just having the term "tender" on the label is not associated with generally higher priced product than not having that term.[6]

[6] We did sensitivity analysis of the reported regression results to determine whether the estimated coefficient on the "Tender" variable was sensitive to including the "TenderPrem" variable since there is some overlap of these variables. The sensitivity analysis indicated that the "Tender" coefficient estimate is somewhat sensitive to including "TenderPrem" in the model as its estimate went from 0.16 including "TenderPrem" to 0.97 when "TenderPrem" was excluded. However, the "Tender" coefficient was not statistically significantly different from zero ($p<0.15$) in either model.

Implications of Retail Steak Price Analysis

Steak prices vary largely across stores and product lines. With prices ranging from $4.99/lb to $19.99/lb, there is apparently substantial market segmentation. However, fully explaining the reasons for price differences is not easy. We focused primarily on product label characteristics in our valuation assessment. However, these do not transmit the full variability differences in prices. Parcell and Schroeder (2007) were able to explain similar variability in steak prices in their larger study using panel diary data. Dutton et al. (2007) explained more variation in steak prices in their data set and their study deserves more attention as it contains more details than our simpler model estimated here. However, their model did not test for the value of tenderness labels specifically.

Tenderness was one of our variables of considerable interest. The term "tender" on the label did not add a statistically significant price premium. As far as we know, we are the first to test the market price for this specific product label. Not finding tenderness significant is somewhat perplexing on the surface given the overwhelming information presented from past research discussed earlier regarding studies showing consumer willingness to pay premiums for tender beef steaks. We hypothesize that one reason we do not see a premium for "tender" on the product label is because the term is not particularly meaningful since it has no standard benchmark. In fact, in our data set of 112 steaks, the lowest priced product in our sample, a $4.99/lb bone-in ribeye Select steak, contains "tender" on the store-branded label. Maybe this $4.99/lb steak is tender, maybe not. We did not sample the product. However, nothing that we could tell from the product label would indicate anything was done to ensure or enhance tenderness. Perhaps retailers are aware of the wealth of research indicating how much consumers care about beef steak tenderness and some use this term to attract customers. This finding may provide additional motivation for the current USDA AMS efforts to develop beef tenderness grading standards.

We found a premium for tender premium products, those that have tenderness assurances associated with them beyond just putting the term "tender" on the package label. The premium for these products was $1.82/lb which is about double what Platter et al. (2005) estimated typical consumers would pay for a "very tender" relative to a "slightly tough" steak of about $0.95/lb ($2.09/kg) and what they found the difference was for "very tender" compared to "very tough" of $1.16/lb. Our estimate is larger than Lusk et al. (2001) who estimated consumers would pay $1.23/lb to upgrade from a "tough" to a "tender" steak in blind taste tests of unlabeled product. However, Lusk et al. (2001) also found that when you modified the information provided consumers in the taste test by informing them which steak was more tender prior to their tasting the products, they were willing to pay $1.84/lb – nearly identical to our estimate. Important to keep in mind in comparing estimates is that premium tender products in the retail store are likely not targeting the "typical" or "average" consumer, but instead attracting a consumer who places greater than average value on tenderness assurance.

Results here, together with those from the studies by Parcell and Schroeder (2007) and Dutton et al. (2007), suggest continued efforts to assess retail beef product labeling claims and related pricing are needed. We recommend when future national retail beef tenderness and related studies are completed by NCBA that detailed data related to product prices and labeling, as well as other potentially important value information, be collected together with the product quality and meat tenderness attributes that have been collected in the past (e.g., George et al., 1999; Brooks et al., 2000). The national beef tenderness benchmarking surveys provide essential data about the profile of beef products in the marketplace, we need more information about product labeling claims, pricing, and whether labeling is consistent with eating

experience. This information would be highly valuable in guiding beef grading and labeling standards. For example, since tenderness is such an important beef steak attribute to consumers, using the term "tender" on the label if the product may not actually be tender, is likely to harm overall beef demand as some customers will undoubtedly be dissatisfied with the eating experience relative to tenderness of the product.

Tenderness Program Highlights

Branded beef initiatives targeting beef tenderness as one of their bundle of product assurance attributes have developed over the past few years. To gain a perspective of the types of programs that offer beef products with a tenderness guarantee, we completed an overview and provide a summary here of selected programs. This is not an attempt to be a comprehensive assessment of all beef tender assured programs and inclusion here is not endorsement of, nor is exclusion, denouncement of, any specific programs. Reviewing the selected tenderness assurance programs makes it apparent that there are a variety of branding efforts, numerous companies involved in product ownership and alliances involving tender assurances, and different methods being used to assure tender products (table 6). The products in our review all began their current programs since 2000. Some include several parties directly in an alliance from producers through retailers, such as the Cattlemen's Collection which includes ranchers, Cargill beef packer, and Kroger supermarket vertical alliance. However, some programs represent a single entity in the vertical market chain such as Albertson's Blue Ribbon.

Tenderness is assured in a number of different ways by existing programs including production through processing protocols. For example, some of the programs have breed requirements such as Angus (Creekstone) or Brahman-influenced or Beefmaster (Nolan Ryan's); most have a production system that includes grain feeding of cattle; most indicate quality grade requirements; most use some form of product aging; and many have developed a technology to either audit and/or test for tenderness attributes. Nearly every tenderness program includes USDA certification or mentions other USDA inspection in their product specifications. This suggests third-party verification is considered valuable in such programs. Nearly every program also indicates some type of production and/or processing technology that they use that is unique, a closely held secret, and/or patented by their program. Important to note is that tender beef programs also typically have other desirable product attributes that they are bundling with tender verification such as Creekstone's Natural Angus. Most beef tenderness programs explicitly offer some type of money back guarantee, with double your money back or a replacement product plus money back guarantees to unsatisfied customers.

Table 6. Summary of Selected Beef Tenderness Assurance Programs

Product / Year Start	Company	Alliance	Tenderness Guaranteed/Verified	How Process is Guaranteed/Verified
Blue Ribbon Feb. 2004	"Albertsons Blue Ribbon", "Jewel Blue Ribbon" and "Lancaster Blue Ribbon"	Alliance with stores where Blue Ribbon sold No vertical integration applied	Guaranteed twice: guaranteed for satisfaction on tenderness, juiciness, and flavor. If consumers are not happy with purchase, Albertsons will refund your money and replace their meat with another.	USDA inspected
Cattlemen's Collection May 2001	Co-op Rancher's Renaissance, partnered with Cargill Meat Solutions & King Soopers/City Market stores of Kroger	Ranchers Renaissance is vertically integrated, value chain alignment cattle marketing cooperative starting with the cow/calf producer Co-op members own or manage upwards of 200,000 cows in seven feedyards	- Use electronic ID, each rancher keeps records. Feedlots have seven standard data fields they complete, Excel provides carcass data - Employ a number of methods to help members meet specs; including health and management protocols for each stage - Carcass specifications: Low-Choice to High-Select quality grades and ribeye areas of 15 inches or less - Beef made tender through audited, quality control steps used throughout entire production chain - Sold as "Verified Tender." If consumers are not happy, they can return the product to the store	- Use Warner-Bratzler shear force tests tender beef as that which could be cut with 10 pounds of force or less - Considered "Verified" because they developed comprehensive Hazard Analysis Critical Control Point (HACCP) plan modeled after one developed by Texas Cattle Feeders Association.
Creekstone Farms Premium & Natural Black Angus Beef May 2005	Creekstone Farms	Own their own processing facilities	- Creekstone is Guaranteed Tender(TM) and produced under a unique "Tenderness Management" system - Black Angus cattle finished on a corn-based ration and aged - Requires all animals be on a corn-based feed ration for a minimum of 100 days, and be aged a minimum of 14 days	- USDA Process-Verified for Tender Beef and USDA Certified - Use electronic carcass stimulation to enhance tenderness, product aging guidelines, and shear force testing to verify tenderness
Harris Teeter *Rancher* Tender Verified Beef 2003	Retail program through Rancher's Renaissance	Beef value chain from ranchers, through Rancher's Renaissance then to Harris Teeter	- Harris Teeter carries a double your money back guarantee on all products - Their ranchers follow quality-control guidelines that encompass grain feeding, health monitoring and quality checks	- From rancher to retailer, beef is checked and tracked to make sure it meets guidelines for quality and tenderness. Then it is stamped as "Tender Verified"

Table 6. Summary of Selected Beef Tenderness Assurance Programs (continued)

Product / Year Start	Company	Alliance	Tenderness Guaranteed/Verified	How Process is Guaranteed/Verified
Nolan Ryan's Guaranteed Tender Meats 2000	Started by Nolan Ryan, marketed through Beefmaster Cattlemen LP	- Bos Indicus-influenced & Beefmaster cattle raised in Texas by ranchers in Beefmaster Cattlemen LP -Processed by Sam Kane Processors, Inc - Sold at Super S Foods Stores, Kroger, Tom Thumb and Randall's supermarkets, and Fry's	- No growth-enhancing antibiotics and hormones during the last 100 days of feeding - Provide money back guarantee on tenderness if customer is not happy	- USDA reviews production practices and monitors compliance - Tenderness assured by Select carcasses, with yield grades lower than 3, weight and ribeye area specs., and devoid of visible defects. Select carcasses with the SmartMV BeefCam (used only on Ryan-brand beef). - Electrically stimulated and aged at least 14 days before they are shipped to retail warehouses.
Rancher's Reserve 2002	Brand owned by Safeway and supplied exclusively by Cargill Meat Solutions (CMS)	Alliance with Safeway and Cargill Meat Solutions.	- Verified Tender process to ensure tenderness guarantee, include: grain feeding, hand-selection of final product, hand trimmed, middle meat cuts aged 14 days - High Select and Low Choice. Priced higher than commodity beef of the same grade less than Premium Choice brands - If dissatisfied, Safeway will refund money, and give customer another package of meat, the same cut of equal or higher value - CMS partner with MMI Genomics, Inc. to launch two new breeding tools for the cattle industry: Tru-Marbling[TM] and Tru-Tenderness[TM]. - Based on MetaMorphix's Genius- Whole Genome System[TM], Tru-Marbling and Tru-Tenderness are DNA based selection products that allow livestock breeders to determine genetic potential of beef cattle to express desirable traits	- Slice Shear Force (SSF) cores from the longissimus muscle, a thin slice (about 0.5 in. thick and 2 in. long) - Accurately classifies carcasses as tender, tough or intermediate 94% of time -Use electro-stimulation & mechanical stretching patented by CMS -Utilize vision cameras and electronic testing to sort carcasses that qualify - Tenderness-tested at least 15 carcasses from 1,300 suppliers as a tenderness audit -Randomly test carcasses with SSF every day in three different labs

Table 6. Summary of Selected Beef Tenderness Assurance Programs (continued)

Rancher's Registry 2000	Cargill Meat Solutions	-Initially, RR product was supplied by 4 Cargill feedyards + multiple Alliances (Rancher's Renaissance and Friona Industries) with several feedyards. -1st retail customer was Kroger - - Denver Division (King Soopers and City Market) + their Atlanta Division = approx 300 retail stores.	-Primary reason - - control cattle type focusing on tenderness + provide beef fed supplemental Vitamin E to extend shelf life. Vitamin E supplementation was discontinued in 2005. -RR is CMS Brand, all cattle must be processed in a CMS plant to receive their patented processes for tenderness. -CMS delivers 90% (or higher) tender beef (middle meats) by day 14 of postmortem aging. - Individual retailers offer their own guarantees - - i.e., replace meat plus give your money back. Multiple retailers (approx 2500 stores) offer exclusive RR beef today (Safeway, Harris Teeter, Hy-Vee, Super Targets, Spartan Stores).	- Test randomly 750- 1000 carcasses per week in U.S. plants based on the USDA slice shear force test (day 14 aging) in one of three CMS tenderness laboratories. -Constantly testing various non-invasive (pulling steaks plus staffing labs costs CMS millions of $ each FY) technological systems to measure tenderness on carcass basis - Individual retailers vary in method of validating tenderness (from staffing and operating their own lab to outsourcing shear force testing) - VerifEYE food safety technology used, but unrelated to tenderness

Tenderness Valuation Grid

Given the demonstrated demand by consumers for tender beef products, and various tender beef programs being developed, an important objective of this project was to develop and evaluate a tenderness-augmented grid pricing system for fed cattle. Grid pricing has been a common way to value carcasses according to individual carcass merit associated with quality and yield grades in addition to other characteristics of carcasses that include weight, age, etc. Use of grid pricing, relative to more traditional dressed- and live-weight valuation, has been widely researched and is well documented as providing more direct premium and discount signals to cattle feeders (e.g., Johnson and Ward, 2005). The purpose here is to go beyond grid pricing by developing a tenderness-augmented grid pricing system.

The most common objective mechanized methods used to assess beef tenderness are Warner-Bratzler shear force (WBSF) and slice shear force (SSF) (see Huffman et al, 1996; Boleman et al., 1997; Shakelford et al., 2001; Wheeler, Shackelford, and Koohmaraie, 2004). Shear force technology involves removing a core from the strip loin of the beef carcass that is approximately 1.25 centimeters in diameter (Wheeler, Cundiff, and Koch, 1994). The core is cooked and sliced using one of the WBSF or SSF instruments. The amount of force required to slice the meat determines its tenderness level. A lower value indicates less force required to slice the meat and thus a more tender meat product.

WBS and SSF measures more accurately predict consumer evaluation of meat product tenderness than USDA quality grades. Wulf et al. (1997) reported a correlation between shear force and consumer sensory panel rated meat product tenderness of -0.76 (lower shear force had greater sensory panel tenderness ratings). Shackelford et al. (1999) confirmed Wulf et al. (1997) results finding a correlation of -0.77 and they also estimated a correlation of -0.82 between consumer sensory evaluation of tenderness and WBSF and SSF, respectively. Wheeler, Shackelford, and Koohmaraie (2004) found an R^2 between SSF and untrained consumer valuation of 0.85. Here, we use WBSF as a predictor of beef tenderness.

The next step in augmenting current grid pricing using WBSF tenderness measures is to determine a tenderness premium/discount schedule to incorporate into the grid pricing system. Platter et al. (2005) estimated an equation for consumer WTP for tender beef strip loin steaks based on experimental data as:

(1) $\text{WTP (\$/kg)} = 10.30 - 1.0165 \times \text{WBSF}$

When converted to \$/lb, using the conversion rate of 2.204623 lbs per 1 kg, WTP is:

(2) $\text{WTP (\$/lb)} = 4.672001 - 0.461077 \times \text{WBSF}$

This gives the value (\$/lb) that consumers are willing to pay for tenderness of beef as measured by WBSF change. We distribute this amount over the percentage of the carcass for which tenderness matters. Roughly 17% to 22% of hot carcass weight is comprised of ribeye, top sirloin, bottom sirloin, strip loin, tenderloin and top round (Foutz et al., 1997 and Wheeler et al., 1997). We use a rough midpoint and assume that 20% of the hot carcass weight would have a tenderness premium or discount driven by equation (2) and the remaining 80% of carcass value is invariant to WBSF measures on the loin. This is a debatable assumption as it assumes that tenderness only matters on 20% of the carcass that comprises predominantly steak products. Tenderness of other beef cuts (e.g., roasts) likely matter to consumers as well, but we ignore this issue in the current analysis.

Beef flavor is strongly associated with beef marbling which is the main driver of quality grades (Smith et al., 1980 and Tatum, 2008). Flavor has been demonstrated as a very important product attribute affecting consumer eating experience (Killinger et al., 2004). Traditional grids with premiums and discounts

for marbling levels (quality grade) reflect this flavor valuation difference. Thus, we augment, rather than replace, current grid systems with Platter's estimated tenderness value equation by adding a tenderness premium to tender carcasses and discounting tough carcasses in addition to traditional quality and yield grade grid premiums and discounts.

To determine the tenderness premium schedule we modify the equation given in Platter et al. by adjusting the constant term in equation (2) so that we can establish a tenderness base that will allow for those carcasses that are more tender than the base WBSF to garner a premium and those that are more tough to be discounted. To determine the appropriate modification we relied on past literature that has estimated WBSF thresholds associated with tenderness classifications.

Platter et al. (2005) report four thresholds of tenderness: "Very Tender", "Slightly Tender", "Slightly Tough" and "Very Tough". The transition from slightly tender to slightly tough is at a WBSF value of 4.4 kg. This is consistent with previous studies. Boleman et al. (1997) give three levels of tenderness: "Tender", "Intermediate" and "Tough" with WBSF ranges for these being 2.27−3.58, 4.08−5.4 and 5.9−7.21, respectively. The median of the intermediate group is 4.74. Wheeler, Shackelford and Koohmaraie (1997) found that at a WBSF level of 3.0 or less 100% of steaks are accepted as tender and for WBSF of 5.7 and higher, 100% of steaks were considered tough. Therefore, they set levels for three thresholds giving a median value (of the intermediate threshold) of 4.35.

Given this myriad of similar thresholds, we settled upon that of Shackelford et al. (1991) who concluded a WBSF of 4.6 was the threshold for moving from tender to tough steaks. Thus, any carcass with a 4.6 kg WBSF or higher would receive a discount and any carcass with a WBSF less than 4.6 would receive a premium in accordance with the following modification to equation (2) after adjusting the constant term to account for the 4.6 WBSF base (applied to 20% of carcass weight).

(3) Tenderness Premium ($/lb.) = 2.12095 – 0.461077×WBSF

Or in $/cwt:

(4) Tenderness Premium ($/cwt) = 212.095 – 46.1077×WBSF

In (4) a WBSF value of 4.6 kg would have a tenderness premium of $0/cwt and each 1 kg difference in WBSF relative to 4.6 would be associated with a $46.11/cwt premium or discount times 20%, the percentage of the carcass this applies to, or $9.22/cwt price change.

An argument could be made for assigning a different base for tenderness premiums and discounts. In particular, one could argue that 4.6 kg being a threshold for slightly tender and slightly tough carcasses might represent too high of a WBSF to start from as a base as it would result in a premium for the typical fed animal in the population today. For example, Brooks et al. (2000) report least squares means Choice WBSF values for Ribeye, Top Loin, T-bone, and Top Sirloin ranging between 2.8 and 3.0 (2.8 to 3.1 for Select) in the 1998 National Beef Tenderness Survey. George et al. (1999) report WBSF values of 3.4 for Choice (3.5 for Select) Top Sirloin and 2.9 for Choice (3.2 for Select) Strip Loin. Voges et al. (2007) used a cutoff point between *tender* and *intermediate* of about 3.9 kg and they reported mean WBSF values for Top Choice grade Top Sirloin of 2.8 kg and Ribeye of 3.0 for foodservice steaks from the 2006 National Beef Tenderness Survey. For carcass data used to exemplify impacts of a tenderness premium in this study (discussed below), the median WBSF value was 3.8. Based on past studies, if we wanted to set a base for tenderness that would leave the average price for fed cattle approximately unchanged relative to current price by augmenting current grids with a tenderness premium, the base of 3.8

kg for WBSF might be more reasonable than a base of 4.6. In such a case, the revised equation 4 would be (recall this applies to only 20% of the carcass weight):

(5) Tenderness Premium ($/cwt) = 175.21 – 46.1077×WBSF

In (5) a WBSF value of 3.8 kg would have a tenderness premium of $0/cwt.

Based upon our earlier discussion, the tenderness-augmented grid schedule used here are likely conservative in nature. Premiums at retail could be quite a bit larger than those used in our 3.8 kg tenderness-augmented grid. That is, from table 2, the predicted premium for tender steak, based on previous literature would be $1.84/lb[7], estimates from our retail survey revealed a premium of $1.82/lb for a "Tender Premium" steak (table 5), and Lusk et al. estimated a premium of $1.84/lb when you tell the consumer that a steak is assured tender relative to a tough steak. Each of these estimates is greater than the amount implied from equations (5) in going from a tender to a tough steak of about $1.16/lb (Platter et al., 2005).

An illustration of these two tenderness premiums is presented in table 7 and figure 3. For each base price considered (WBSF 4.6 kg and 3.8 kg), two different carcass premium schedules are estimated. For each base, the first schedule is what is referred to as "continuous" which simply uses equations (4) or (5) to estimate a premium or discount as WBSF varies that is continuous based on the respective equations.

Important to recognize from an industry perspective is that if a tenderness premium schedule were widely adopted, both producer supply response and consumer demand response would be likely. That is, providing premiums for tender carcasses, would encourage producers to supply more carcasses possessing more tender beef products. This would put downward pressure on market derived tenderness premiums. In addition, more consistently and predictably tender beef product offerings at retail and food service would result in higher consumer demand. This would support tenderness premiums. Whether the supply or demand impact would be greater is uncertain. However, because of a very inelastic (rigid in terms of changes in price triggering small changes in quantity supplied) supply response, a supply adjustment would likely take much longer than the improvement in demand. This would support tenderness premiums, at least in the short run.

The second type of tenderness grid developed here, referred to as "Step-Wise", uses a step-wise premium/discount schedule. In the step-wise schedule, the thresholds to change steps were selected using the thresholds from Platter et al. (2005) of 3.40 kg or less being *very tender*, 3.41−4.40 being *slightly tender*, 4.41−5.40 being *slightly tough*, and greater than or equal to 5.4 being *very tough*. For example, for the 4.6 kg base, the step-wise shifts to a premium at WBSF of 4.4 as we move from *slightly tough* to *slightly tender* at that point and another step occurs at 3.40 kg when we go from a *slightly tender* to *very tender* carcass. The same thresholds for each step apply to the 3.8 kg base schedule. The values of the premiums or discounts in the stepwise grids were calculated based on what we might expect the percentage distribution of cattle that would fall into that step would receive if the schedule were continuous instead of stepwise. The percentages were estimated by using the percentages of carcasses from a sample of 3,154 carcasses described below that were present in each WBSF range multiplied by the continuous premium or discount. In essence, the step-wise premiums or discounts are the weighted-averages of the continuous premiums or discounts for each WBSF grouping with the weights being the percentage of carcasses in that group expected to fall into each shear force range.

[7] From the estimated regression reported in table 2: Tenderness Premium = -0.142 + 3.718×0 + 0.858×1 + 1.124×1 = $1.84/lb assuming *Sensory* = 1 and *Revealed Tenderness* =1.

A continuous tenderness-augmented premium schedule is more efficient from the perspective of sending continuous value signals to cattle producers. However, a step-wise system might be easier to implement and use. Further, beef products will likely not be sold at the wholesale level with price differentials that change continuously with tenderness levels. Thus, operationally, step-wise premiums might make more sense as well. Nonetheless, to keep analysis from becoming too voluminous we analyze only continuous tenderness-augmented premium grids.

The sample tenderness grids imply a premium of $5.53/cwt for a carcass with a shear force of 4.00 kg if the base is 4.6 kg or a discount of $1.84/cwt for this carcass if the base were selected to be 3.8 kg (table 7 and figure 3). Premiums differ by $7.38/cwt between the two different tenderness base grids (3.8 and 4.6) simply reflecting differences of $7.38/cwt in changing from a 4.6 kg to a 3.8 kg base.

Table 7. Sample Carcass Premium Schedule for Tenderness, Step-Wise and Continuous with 3.8 kg and 4.6 kg WBSF as Base

WBSF (kg)	Continuous Carcass Premium ($/cwt)	Step-Wise Carcass Premium ($/cwt)	Continuous Carcass Premium ($/cwt)	Step-Wise Carcass Premium ($/cwt)
	Base WBSF of 4.6 kg		Base WBSF of 3.8 kg	
2.60	18.44	12.93	11.07	5.55
2.80	16.60	12.93	9.22	5.55
3.00	14.75	12.93	7.38	5.55
3.20	12.91	12.93	5.53	5.55
3.40	11.07	12.93	3.69	5.55
3.60	9.22	6.59	1.84	0.00
3.80	7.38	6.59	**0.00**	0.00
4.00	5.53	6.59	-1.84	0.00
4.20	3.69	6.59	-3.69	0.00
4.40	1.84	6.59	-5.53	0.00
4.60	**0.00**	0.00	-7.38	-9.88
4.80	-1.84	0.00	-9.22	-9.88
5.00	-3.69	0.00	-11.07	-9.88
5.20	-5.53	0.00	-12.91	-9.88
5.40	-7.38	0.00	-14.75	-9.88
5.60	-9.22	-12.52	-16.60	-19.90
5.80	-11.07	-12.52	-18.44	-19.90
6.00	-12.91	-12.52	-20.29	-19.90
6.20	-14.75	-12.52	-22.13	-19.90
6.40	-16.60	-12.52	-23.98	-19.90
6.60	-18.44	-12.52	-25.82	-19.90
6.80	-20.29	-12.52	-27.66	-19.90
7.00	-22.13	-12.52	-29.51	-19.90
7.20	-23.98	-12.52	-31.35	-19.90

Figure 3. Sample Carcass Premium Schedules for Tenderness

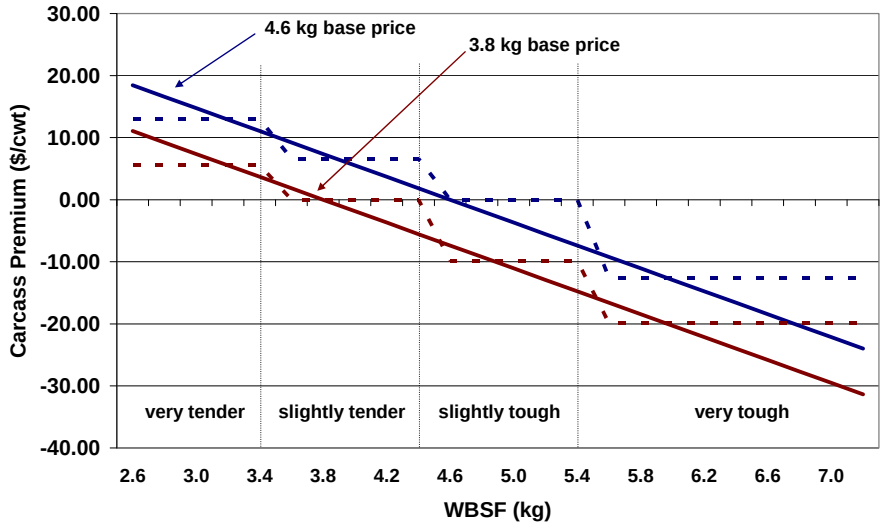
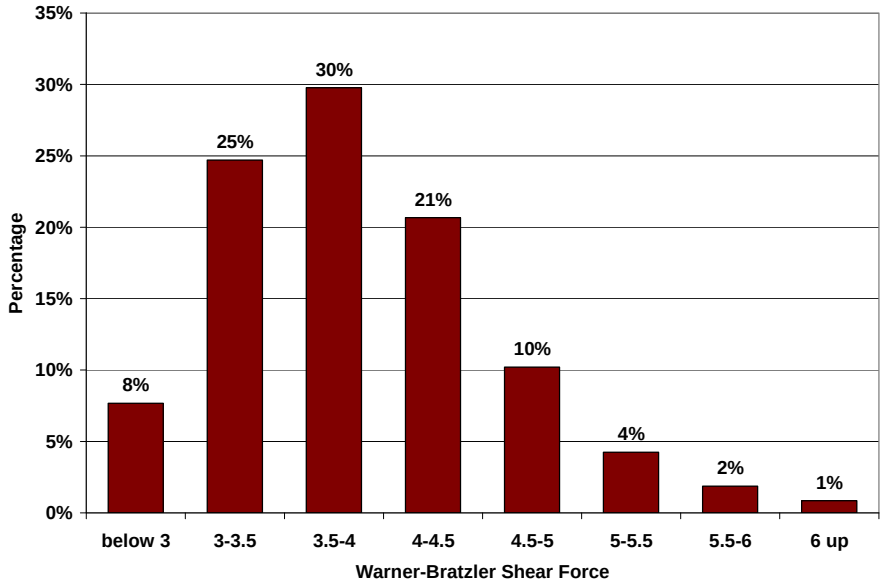


Figure 4. Distribution of Warner-Bratzler Shear Force Beef Tenderness Measures for Sample of 3,154 MARC Carcasses



Data and Methods

Carcass data from the U.S. Meat Animal Research Center (MARC) were used to exemplify how a tenderness-augmented grid pricing system would affect fed cattle prices. MARC collected traditional fed cattle valuation measures (e.g., carcass weight and USDA quality and yield grades) and WBS values for 3,563 beef cattle carcasses. In addition, consumer sensory panel ratings were collected for tenderness, juiciness and flavor[8] on a steak from each of the carcasses. Carcasses that weighed more or less than acceptable ranges as defined by typical grids (i.e., carcasses weighing less than 600 lbs or more than 900 lbs) were deleted, reducing the number of carcasses used in the analysis to 3,154. The data were used to assess how cattle would have been valued under traditional dressed and grid pricing systems and compared with valuations based upon actual meat tenderness as assessed by WBSF. Table 8 presents summary statistics of the carcass data obtained from MARC.

Figure 4 illustrates the distribution of WBSF measures for the 3,154 carcasses. The majority of carcasses fall between a shear force of 3 and 5 kg. About 30% of carcasses have a shear force of 3.5 kg or less and about 60% have with a 3.5 to 5 kg shear force with 10% of carcasses having greater than 5 kg WBSF.

[8] Ratings were based on a scale of 1 to 8 with 1 being the worst and 8 the best.

Table 8. Summary Statistics of Carcass Data Obtained from MARC

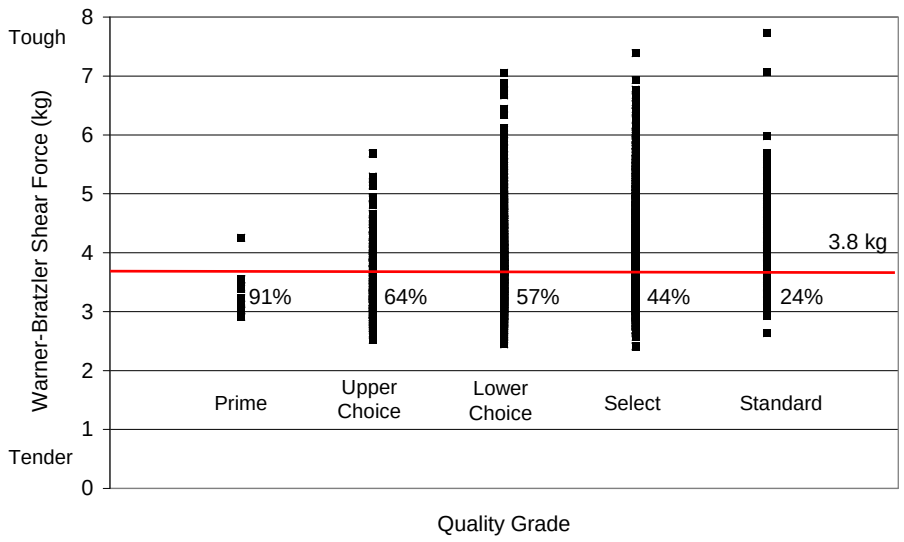
	Count (%)	Mean	Std. Dev.	Minimum	Maximum
Live Weight (lbs.)		1,199.5	114.5	892.0	1,544.0
Hot Carcass Weight (lbs.)		736.4	73.3	600.0	900.0
Dressing Percentage		61.4	2.1	50.3	72.4
Marbling Score[a]		504.2	67.6	280.0	890.0
Quality Grade[b]		1.6	0.7	0.0	4.0
Prime	11 (0.3%)				
Upper 2/3 Choice	182 (5.8%)				
Lower 1/3 Choice	1,460 (46.3%)				
Select	1,397 (44.3%)				
Standard	104 (3.3%)				
Yield Grade		2.9	0.8	0.4	6.9
Yield Grade 1	415 (13.2%)				
Yield Grade 2	1,299 (41.2%)				
Yield Grade 3	1,097 (34.8%)				
Yield Grade 4	302 (9.6%)				
Yield Grade 5	41 (1.3%)				
Warner-Bratzler Shear Force		3.9	0.7	2.4	7.7
Tenderness Sensory Score[c]		4.9	0.8	1.5	8.0
Juiciness Sensory Score[c]		5.1	0.5	3.5	7.1
Flavor Sensory Score[c]		4.9	0.4	2.9	6.4
Number of Observations	3,154				

[a]200=Practically Devoid, 300=Traces, 400=Slight, 500=Small, 600=Modest, 700=Moderate, 800=Slightly Abundant, 900=Moderately Abundant

[b]4=Prime, 3=Upper Choice, 2=Lower Choice, 1=Select, 0=Standard

[c] Sensory panel rating assigned ranging from 1=least desirable to 8=most desirable

Figure 5. Warner Bratzler Shear Force Values by Quality Grade



Further dissection of the WBSF values for the carcasses analyzed is provided in figure 5 where we break the shear force values across quality grade. Each box in figure 5 represents one carcass. Because the number of carcasses in each quality grade is difficult to decipher in figure 5, we also report the percentage of carcasses by each quality grade that are less than 3.8 kg WBSF. For example, 91% of the Prime carcasses have a WBSF value less than 3.8 kg (only one Prime carcass had a value higher than this). As quality grade declines from Prime to upper Choice and so forth, the percentage of carcasses that have a WBSF less than 3.8 decline with only 44% of Select and 24% of Standard carcasses having a WBSF less than 3.8. Important to note is that many Select carcasses have WBSF values that indicate more tender steak products than either lower or upper Choice grade carcasses. This means that for a tenderness-based program, many Select grade steaks should garner a premium for tenderness (after adjusting for the Select discount). Similarly, many Choice steaks would receive a tenderness discount.

The objective here was to compare tenderness-augmented grids with standard grids as an illustration of the value differences of cattle sold on current grids relative to the tenderness premium schedule presented above. In this illustration we assign traditional and tenderness-augmented grid values to the MARC carcasses. To assign grid values to these carcasses, we start with a base dressed fed steer price which was obtained from the USDA-AMS *5 Area Weekly Weighted Average Direct Slaughter Cattle* report for the week of September 30, 2007. The same dressed steer price was used as the base price for the traditional grid and tenderness grids. This price is based on a 50% Choice and 50% Select grade pen of cattle. The base price was $149.40/cwt.

USDA-AMS *National Weekly Direct Slaughter Cattle – Premiums and Discounts* reported prices were used for grid premiums and discounts for the same week. Because we use a 50% Choice, 50% Select carcass as the base carcass price, grid premiums and discounts added to the base are adjusted accordingly since grid premiums and discounts reported by USDA are based on a pen of 100% low choice cattle (i.e., the low Choice premium published by USDA is $0/cwt). To make this adjustment, low Choice carcasses were assigned a premium of one-half the Select discount and Select carcasses a discount of one-half the Select discount and all other grid quality grade premiums and discounts were adjusted relative to these. The Choice-to-Select price spread during the week of September 30, 2007 was $8.50/cwt. The premium for Prime relative to Choice was $10.77/cwt ($15.02/cwt when adjusted up $4.25/cwt relative to a 50% Choice 50% Select price). The grid premiums and discounts used to value traditional grid cattle are in table 9.

Table 9. Grid Premiums and Discount Schedule used in the Traditional Grid Analysis

Carcass Grade	USDA Quoted Premium/Discount ($/cwt)	Base Price Adjusted Premium/Discount ($/cwt)
Prime	10.77	15.02
Upper Choice	2.58	6.83
Lower Choice	0.00	4.25
Select	-8.50	-4.25
Standard	-17.00	-12.75
YG < 2	2.92	2.92
YG 2-2.5	1.38	1.38
YG 2.5-3	0.96	0.96
YG 3-3.5	-0.08	-0.08
YG 3.5-4	-0.08	-0.08
YG 4-5	-13.92	-13.92
YG > 5	-19.33	-19.33

Source: USDA quoted premiums and discounts are for week of September 30, 2007

For any carcass whose calculated value based on the applied tenderness discount was lower than the cull cow price, a cull-cow price of $121.25/cwt carcass weight was used as a lower-bound of what a very tough carcass would be worth.

To obtain a tenderness-augmented price grid, we took the calculated grid value of each carcass and added to it a premium or discount based upon equations (4 and 5) associated with the WBSF value for tenderness of the carcass. This creates an adjustment to the carcass value associated with the tenderness proxy while letting quality grade premiums and discounts represent the marbling value.[9]

Results

Table 10 reports summary statistics of valuing the 3,154 MARC carcasses using three different grids 1) a traditional grid, 2) a 3.8 kg WBSF base tenderness-augmented grid, and 3) a 4.6 kg WBSF base tenderness-augmented grid. The traditional grid serves as a benchmark from which to compare the tenderness-augmented grids. The 3.8 kg tenderness base grid has a net price that, by design, is very similar in magnitude on average to the traditional grid with the traditional grid price being $0.65/cwt higher across all carcasses than the 3.8 kg base grid price. The 4.6 kg tenderness base grid has a net price for all cattle that is just under $7/cwt higher than the traditional grid. We will focus our discussion more on the 3.8 kg base than the 4.6 kg base as the 3.8 kg base may be more feasible for adoption given its similar overall average price to traditional grid valuation.

The tenderness-augmented grid results in considerably greater (about twice as large of standard deviation) variation in carcass valuation than traditional grids across all carcasses. Referring back to figure 5, this is not particularly surprising because several upper Choice and many lower Choice grade carcasses have WBSF values of 5 kg or greater, implying a tenderness discount on these carcasses of at least $11/cwt with the 3.8 kg tenderness base price (table 7).

[9] The quality grade premiums or discounts indeed likely reflect partly flavor and partly tenderness related meat product attribute values. As such, an argument could be made that the quality grade premiums and discounts might need to be adjusted downward from current quotes if one accounted for tenderness separately and independently as we do. However, given the poor predictability of tenderness based upon marbling, discussed earlier, we did not feel it was necessary to adjust the quality grade premiums.

Table 10. Summary Statistics of Carcass Valuations for Traditional Grid and 3.8 kg and 4.6 kg WBSF Tenderness-Augmented Grids

Quality Grade	Valuation Method	Mean	Standard Deviation	Minimum	Maximum
		- - - - - - - - - - ($/cwt carcass weight) - - - - - - - - -			
All Carcasses	Traditional Grid	$148.76	$5.88	$125.82	$167.34
	3.8 kg Tender Base	$148.09	$9.28	$121.47	$171.44
	4.6 kg Tender Base	$155.43	$9.40	$121.47	$178.82
Prime	Traditional Grid	$154.06	$7.46	$145.09	$167.34
	3.8 kg Tender Base	$158.48	$6.31	$152.81	$171.44
	4.6 kg Tender Base	$165.85	$6.31	$160.18	$178.82
Upper Choice	Traditional Grid	$152.27	$6.88	$136.90	$159.15
	3.8 kg Tender Base	$154.09	$8.62	$128.52	$168.16
	4.6 kg Tender Base	$161.46	$8.62	$135.90	$175.54
Lower Choice	Traditional Grid	$151.85	$5.58	$134.32	$156.57
	3.8 kg Tender Base	$152.12	$8.40	$121.47	$168.97
	4.6 kg Tender Base	$159.49	$8.42	$121.47	$176.35
Select	Traditional Grid	$145.76	$3.25	$125.82	$148.07
	3.8 kg Tender Base	$144.03	$7.40	$121.47	$159.39
	4.6 kg Tender Base	$151.34	$7.63	$121.47	$166.77
Standard	Traditional Grid	$138.73	$0.95	$136.57	$139.57
	3.8 kg Tender Base	$134.52	$6.81	$121.47	$148.77
	4.6 kg Tender Base	$141.73	$7.22	$121.47	$156.15

Traditional Grid refers to carcasses valued based on traditional quality and yield grade grid.

3.8 kg Tender Base refers to carcasses valued using a tenderness-augmented grid with 3.8 kg WBSF as tender base

4.6 kg Tender Base refers to carcasses valued using a tenderness-augmented grid with 4.6 kg WBSF as tender base

The tenderness-augmented grid results in sizeable premiums on average for higher quality grade carcasses than traditional grid valuation. For example, Prime carcasses on average would receive a $4.42/cwt and upper Choice a $1.18/cwt higher price with the tenderness grid than under the traditional grid. This reflects the fact that many carcasses in higher quality grades have very tender meat. However, many upper and lower Choice quality grade carcasses produce less tender meat than many Select grade carcasses. From figure 5, we saw that 36% of upper Choice and 43% of lower Choice grade carcasses had WBSF values of 3.8 kg or greater. As such, these carcasses would receive tenderness discounts.

A small number of carcasses in the lower Choice grade (0.07%) have such tough meat that they garner tenderness discounts in addition to possible yield grade discounts that would make them worth less than what cull cow carcasses were worth, $121.47/cwt. Such carcasses were valued at the cull cow price as the lower limit. Similarly, 1.7% of Select and 2.9% of Standard grade carcasses would garner tenderness discounts, in addition to any quality and yield grade discounts, severe enough to make the carcasses worth the cull cow price as the lower limit.

Figure 6. Comparison of 3.8 kg Base Tenderness-Augmented and Traditional Grid Carcass Valuation

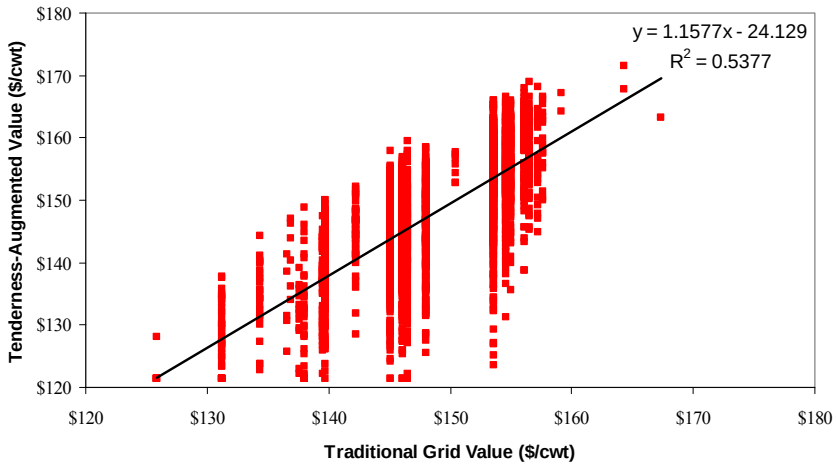


Figure 7. Distribution of Carcass Value for 3.8 kg Base Tenderness Minus Traditional Grid Value

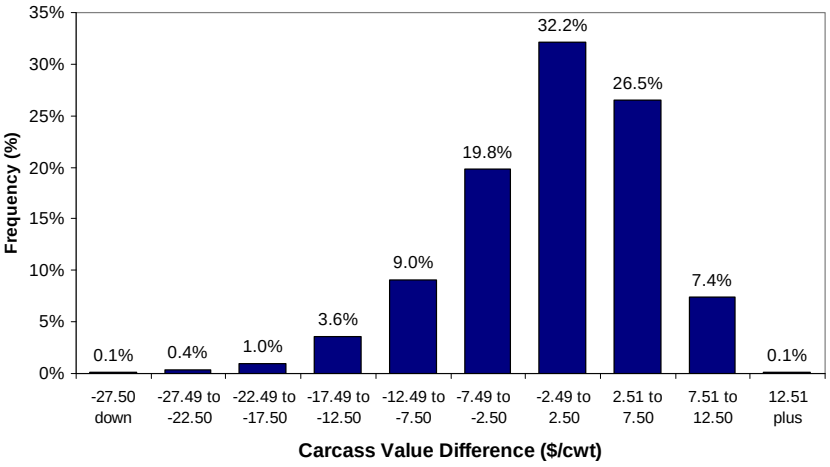
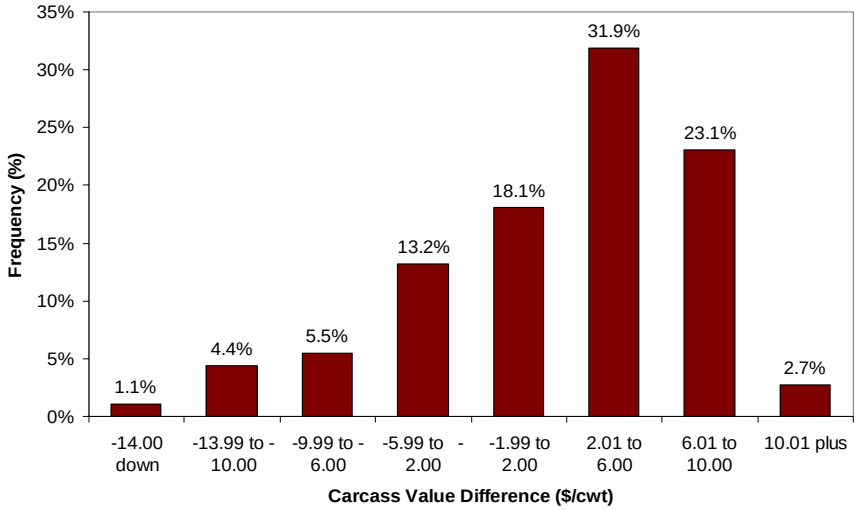


Figure 8. Tenderness-Augment Grid (3.8 kg Base) Minus Traditional Grid Carcass Values - Upper Choice Grade Carcasses



A graphic comparison of the 3.8 kg tenderness base with the traditional grid values across all carcasses is illustrated in figure 6. Each box in figure 6 represents a carcass. This figure indicates the tenderness-augmented grid would substantially re-order the value of carcasses relative to the traditional grid. Figure 7 shows the distribution of the magnitude of premiums or discounts carcasses valued using the 3.8 kg base tenderness-augmented grid would receive relative to the traditional grid. About 35% of carcasses would receive a premium of more than $2.50/cwt under the tenderness-augmented grid relative to a traditional grid with 7% receiving in excess of $7.50/cwt. However, about 34% of carcasses would receive discounts of $2.50/cwt or more under the tenderness-augmented grid with approximately 14% of carcasses realizing a discount in excess of $7.50/cwt. Overall, the average of the absolute value of price differences between the tenderness-augmented grid with the 3.8 kg base and the traditional grid carcass value across all 3,154 carcasses was $4.98/cwt. This number represents the average price adjustment (up or down) carcasses would receive with a tenderness-augmentation to a traditional grid.

Figure 9. Tenderness-Augment Grid (3.8 kg Base) Minus Traditional Grid Carcass Values - Lower Choice Grade Carcasses

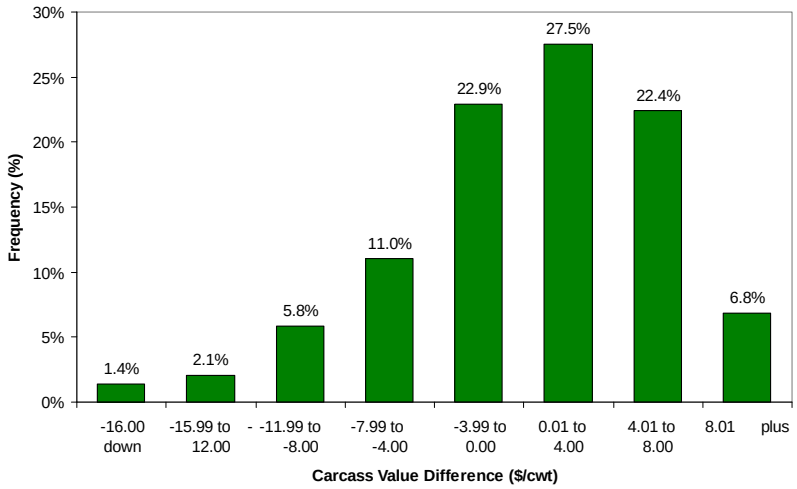


Figure 10. Tenderness-Augment Grid (3.8 kg Base) Minus Traditional Grid Carcass Values - Select Grade Carcasses

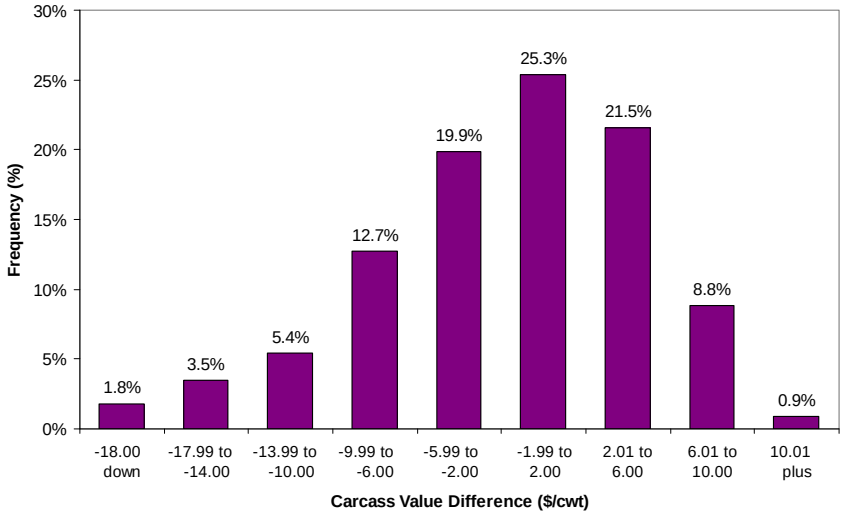
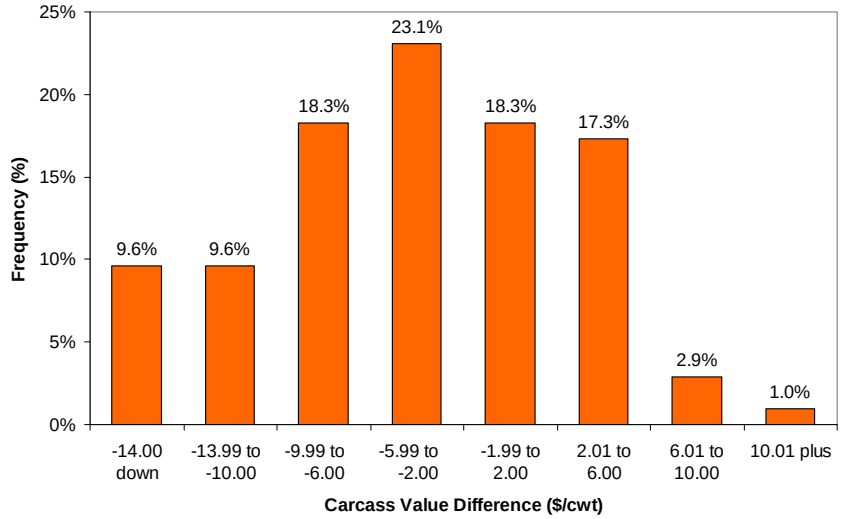


Figure 11. Tenderness-Augment Grid (3.8 kg Base) Minus Traditional Grid Carcass Values - Standard Grade Carcasses



We further break down the premiums and discounts associated with the tenderness-augmented grid by carcass quality grade to illustrate how carcass values would be altered with the tenderness value adjustment within each quality grade. Figures 8-11 illustrate how carcasses in each quality grade would be revalued with the tenderness adjustment (because the data sample has only 11 Prime carcasses, we did not graph the value adjustment distribution for Prime grade carcasses).

Figure 8 reveals that for the upper Choice grade, about 25% of carcasses would receive at least a $6.00/cwt higher price with tenderness premiums than under traditional grids. Approximately 24% of upper Choice carcasses would receive a $6.00/cwt or greater discount because of having relatively tough carcasses. Lower Choice carcasses (figure 9) would also have sizeable value adjustments under a tenderness-augmented grid with about 29% earning a $4.00/cwt or more premium and 20% a $4.00/cwt or larger discount relative to traditional grid valued carcasses. Select (figure 10) and Standard (figure 11) carcasses show similar value realignment when priced using the tenderness grid vs. the traditional grid.

Side-Note on NIR

The tenderness-augmented carcass valuation grid analyzed here relies upon WBSF to objectively assign a shear force value to each carcass to determine the associated tenderness premium or discount. WBSF is well accepted, widely used in research, and broadly understood in industry as a reliable mechanical measure of meat tenderness. However, a significant concern about WBSF is that it is invasive in that is requires a core sample of meat product from each carcass for determining shear force. As such, other technologies have been developed that alleviate this concern, while trying not to lose substantial reliability or accuracy. Near-infrared spectroscopy (NIR) is one recent technological development that may have promise for being more desirable commercially in on-line tenderness testing at the packing plant than WBSF (Price et al., 2007; Rust et al., 2008).

Determining whether NIR is a sufficiently accurate measure of tenderness relative to WBSF is beyond the scope of this research. Early evidence suggests NIR might show promise in being a viable proxy for beef tenderness measurement. Rust et al. (2008) determined that NIR could sort tough from tender longissimus lumborum muscles with 70% certification levels.

They concluded "that NIR scanning offers an in-plant opportunity to sort carcasses into tenderness outcome groups for guaranteed-tender branded programs" (p. 211). If NIR is deemed sufficiently accurate in assigning tenderness measures, the tenderness-augmented grid analyzed here could easily be translated into an equivalent-looking NIR grid if the WBSF values can be converted into NIR measures. That is, if an equation relating WBSF and NIR measures with high correlation and low error exists, the tenderness-augmented grid developed here could be used with NIR measures to replace WSBF. We have not attempted to locate or determine whether such an equation relating these two exists or is sufficiently reliable. Price et al. conclude that NIR is likely more useful for identifying tough carcasses and not for developing a continuous reflection of shear force. This might suggest that if industry were to adopt NIR for identifying tough carcasses, a tenderness-augmented grid may look much more like a crude step function (probably with even fewer steps than we show in figure 3). The result would be less distinction in tenderness levels and premiums and discounts for variation in tenderness. Perhaps this is more practical going forward than a continuous measure of tenderness. However, recognize that important information that consumers demonstrate willingness to pay for is lost when we only sort off tough carcasses from the distribution leaving a distribution of "slightly tough", "slightly tender", and "tender" in the product offering.

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