Using Genetic Testing to Improve Fed Cattle Marketing Decisions

Nathanael M. Thompson
Oklahoma State University
nathan.thompson10@okstate.edu

Eric A. DeVuyst
Oklahoma State University
eric.devuyst@okstate.edu

B. Wade Brorsen
Oklahoma State University
wade.brorsen@okstate.edu

Jayson L. Lusk
Oklahoma State University
jayson.lusk@okstate.edu

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Abstract

We estimate the value of using genetic information in making fed cattle marketing decisions. Our results identified efficiency gains from sorting cattle into marketing groups, including more accurate optimal days-on-feed and reduced variability of returns to cattle feeding. Selectively marketing cattle based on genetic information increased expected profit by $1-$15/head depending on how a producer currently markets cattle, the grid structure, and risk preferences. Although values of genetic information were generally higher than those reported in previous research, they were still not enough to offset the current cost of genetic testing ($40/head).

Keywords: Fed cattle marketing, genetics, molecular breeding value, risk aversion, value of information

Introduction

The beef industry has promoted value-based marketing strategies since the early 1990s in an effort to improve the quality and consistency of beef products (National Cattlemen's Beef Association [NCBA], 1990). Most notably, grid pricing was introduced in the mid-1990s as a way to provide transparent price signals along the entire production supply chain. Traditional cash pricing mechanisms, such as live weight and dressed weight pricing, are not based on the actual quality and yield grade of carcasses. As a result, above-average cattle are paid less than their market value and below-average cattle are paid more than their market value. Therefore, traditional pricing mechanisms inhibit information flow from beef consumers to cattle producers (Feuz, Fausti, and Wagner, 1993; Fausti, Feuz, and Wagner, 1998). Grid pricing, on the other hand, determines value based on the carcass merit of each individual animal. Premiums and discounts that make up the grid are designed to reflect consumer preferences and transmit these signals upstream to cattle producers. Feedback on individual carcass performance and value provides an incentive for producers to make necessary changes to "their breeding, feeding, and sorting programs" (Johnson and Ward, 2005, p. 562).

The National Beef Quality Audit (NBQA) reported that the share of fed cattle marketed on a grid increased from 15% in 1995 to 34% in 2005 (NCBA, 2006). However, grid pricing has yet to become the dominant fed cattle marketing strategy as many projected (Schroeder et al., 2002), accounting for only 40%-45% of fed cattle marketings (Fausti et al., 2010). While there is ample literature investigating producer incentives and disincentives to adopt grid pricing, the fundamental marketing risk created by the system has been identified as the primary barrier to adoption (Fausti, Feuz, and Wagner, 1998; Anderson and Zeuli, 2001; Fausti and Qasmi, 2002). Depending on the sample period, live weight, dressed weight, or grid pricing can have the highest returns, but variability is consistently highest for grid pricing (Feuz, Fausti, and Wagner, 1993; Schroeder and Graff, 2000; Anderson and Zeuli, 2001; Fausti and Qasmi, 2002; Lusk et al., 2003). This problem is further exacerbated by varying levels of risk aversion among cattle producers (Fausti and Feuz, 1995; Feuz, Fausti, and Wagner, 1995; Fausti et al., 2013; Fausti et al., 2014).

The risk associated with buying and selling fed cattle can be broken down into two main components: general price risk and informational (or carcass) risk (Fausti and Feuz, 1995). In this paper we focus on the carcass risk associated with marketing fed cattle. That is, because marketing decisions are made prior to slaughter, carcass quality (yield grade, quality grade, and hot-carcass weight) is unknown. Therefore, better predictions of carcass quality may allow decision makers to improve their marketing decisions. Recent technological advancements in beef production, such as ultrasound technology and genetic testing, have made such information available. However, a producer would only be expected to use this technology if its benefits outweigh the costs. As a result, a branch of the agricultural economics literature evaluating the economic benefits of these technologies has emerged (Fausti et al., 2010).

For example, Lusk et al. (2003) and Walburger and Crews (2004) reported that using ultrasound technology to selectively market cattle, as opposed to simply marketing all cattle on a live weight, dressed weight, or grid basis, increased returns by $4 to $32/head. However, both of these studies held days-on-feed constant when making these comparisons. Koontz et al. (2008) contend that such an approach uses additional information to exploit pricing inefficiencies and is unlikely to change returns to producers in the long run. Therefore, they argue that improving meat quality and beef industry profitability requires changing the product form. For example, they found that the value using ultrasound measurements to sort cattle into groups that were marketed to optimize returns by choosing days-on-feed was between $15 and $25/head, with declining marginal returns as the number of sort groups increased (Koontz et al., 2008).

More recently, advancements in the field of cattle genomics have made genetic marker panels for a variety of traits commercially available. While previous literature has found that there is significant value (up to $60/head) to using genetic information for selecting feeder cattle for placement in the feedlot (DeVuyst et al., 2007; Lusk, 2007; Lambert, 2008; Thompson et al., 2014), this information is not typically available prior to purchasing feeder cattle. Therefore, feedlots are limited to using this information to sort cattle that they already own into management groups that are most likely to achieve similar outcomes, or marker-assisted management (Van Eenennaam and Drake, 2012). In previous research, marker-assisted management has been limited to sorting cattle by optimal days-on-feed. As a result, reported values of genetic information for marker-assisted management have consistently been less than $3/head (DeVuyst et al., 2007; Lusk, 2007; Lambert, 2008; Thompson et al., 2014). Still, there remains potential for using the information derived from genetic testing to improve other management decisions within the feedlot that have yet to be evaluated, including how cattle are fed, how technologies such as implants and beta agonists are utilized, and how cattle are marketed.

Therefore, the objective of this research is to estimate the expected value of genetic information for improving fed cattle marketing decisions, including decisions for both marketing method (live weight, dressed weight, or grid pricing) and timing to market (days-on-feed). Although several previous studies have attempted to estimate the value of genetic information, none have considered the potential of this information to improve fed cattle marketing decisions. In addition, previous research evaluating fed cattle marketing decisions have examined either the marketing method or the optimal days on feed, but both of these decisions have never been evaluated simultaneously.

Data from feedlot cattle are used to estimate regression equations characterizing phenotypic outcomes for average daily gain, dressing percentage, yield grade, and quality grade as a function of live animal characteristics and genetic information. These equations are then used as part of a Monte Carlo integration procedure to estimate expected profit and expected utility for several marketing scenarios. Three baseline scenarios are created in which all cattle are marketed in a single group on a live weight, dressed weight, or grid basis without the use of any information. These baseline scenarios are then compared with alternative marketing scenarios in which additional information is known and used to sort cattle into groups to be targeted to specific marketing methods.

Conceptual Framework

Cattle feeders are assumed to maximize expected utility of profit by choosing both how and when to market cattle. At placement in the feedlot, placement weight and purchase cost are the only variables known with certainty. Other profit determinants are a function of random growth and carcass characteristics, including average daily gain (ADG), dressing percentage (DP), yield grade (YG), and quality grade (QG). Although we assume that output prices are known by the decision maker, it is unknown how animals will perform and, as a result, what weight and carcass quality they will achieve. Therefore, the producers' expected utility maximization problem can be written

$$(1)\quad \max_{\substack{MKT\in\{LIVE,DRES,GRID\}\\ DOF\geq 0}} \iiiint EU[\pi(MKT,DOF,ADG,DP,YG,QG)]\times$$

$$f(ADG,DP,YG,QG)dADGdDPdYGdQG,$$

where $U[\pi(\cdot)]$ is a constant absolute risk aversion (CARA) utility function (Chavas, 2004) and the feeder chooses the marketing method (MKT) and marketing date, or days-on-feed (DOF). Under the assumption of risk neutrality ($U'' = 0$), equation (1) reduces to an expected profit maximization problem. However, depending on risk preferences, decision makers may not always prefer the alternative that generates the highest expected profit. Instead, preferences may also be influenced by the variability or distribution of returns for each alternative. Therefore, in addition to risk neutrality, we evaluate this decision for several levels of risk aversion to determine how producers' attitudes towards risk influence fed cattle marketing decisions.

The three primary methods by which fed cattle are marketed are live weight pricing ($LIVE$), dressed weight pricing ($DRES$), and grid pricing ($GRID$). These three marketing methods differ primarily by whether the buyer or the seller bears the risk of carcass outcomes. When using live weight pricing, the packer and the feeder generally negotiate a carcass price based on the expected quality traits of a pen of cattle assessed through visual appraisal. This carcass price is then converted to a live animal price by multiplying it by the expected dressing percentage. Profit for this scenario can be written

$$\begin{aligned} \pi_{LIVE} &= P_{LIVE} \times FWT(PWT, ADG, DOF) \times (1 - PS) \times (1 - MR) \\ &\quad - PC(PWT, SEX) - FC(DOF) - YC(DOF) - IC(PC, DOF), \end{aligned} \tag{2}$$

where P_{LIVE} is the live weight price, FWT is final live weight which is a function of placement weight (PWT), ADG, and DOF, $FWT = PWT + ADG \times DOF$, $PS \in [0, 1]$ is pencil shrink, $MR \in [0, 1]$ is mortality rate, PC is purchase cost of feeder cattle, FC is feed cost, YC is yardage cost, and IC is interest cost on the purchase of feeder cattle. Under this alternative the buyer takes on all of the carcass risk. Because these characteristics can be difficult to predict preharvest, live prices tend to undervalue high-quality cattle and overvalue low-quality cattle.

Marketing cattle on a dressed basis is similar to the live weight pricing method described above, except that the price is not adjusted for an expected dressing percentage. Instead, the price is paid based on the actual dressed weight, or hot-carcass weight, and the seller assumes the dressing percentage risk. Therefore, profit for dressed weight pricing is

$$(3) \qquad \pi_{DRES} = P_{DRES} \times HCW(PWT, ADG, DOF, DP) \times (1 - MR) - PC(PWT, SEX) \\ - FC(DOF) - YG(DOF) - IC(PC, DOF),$$

where P_{DRES} is dressed weight price and HCW is hot-carcass weight which is a function of PWT, ADG, DOF, and DP, $HCW = [PWT + (ADG \times DOF)] \times DP$. In principle, the dressed price will be comparable to the live price adjusted for dressing percentage for the same pen of cattle. However, over time the average dressed price is expected to be greater than the average live price adjusted for dressing percentage given packers' incentive to offset errors in estimating dressing percentage (Feuz, Fausti, and Wagner, 1993).

Lastly, when marketing cattle on a grid, the seller assumes the yield grade, quality grade, and dressing percentage risk for each individual animal. Profit is

$$(4) \qquad \pi_{GRID} = P_{GRID}(YG, QG, HCW) \times HCW(PWT, ADG, DOF, DP) \times (1 - MR) \\ - PC(PWT, SEX) - FC(DOF) - YG(DOF) - IC(PC, DOF),$$

where P_{GRID} is the grid price which is a function of YG, QG, and HCW outcomes. Although not all grids are homogenous across the packing industry, they generally list a base price (P_{BASE}) for yield grade 3, Choice carcasses weighing between 600-900 pounds. Depending on how each carcass grades this base price is then subject to an additive set of premiums and discounts for yield grade, quality grade, and weight outcomes, $P_{GRID} = P_{BASE} + premiums/discounts(YG, QG, HCW)$. In practice, packers use a variety of methods for determining the base price. Here we use Ward, Feuz, and Schroeder's (1999) formula to determine the base price, $P_{BASE} = P_{DRES} +$

$[(Choice/Select\ spread) \times (plant\ average\ percent\ Select)]$, where we assume the plant average percent Select is equal to the percentage of animals that graded Select or worse in our data set (45%).

Additional information about animal performance provides decision makers the opportunity to improve their marketing decisions by selectively marketing cattle to different marketing methods, as well as adjusting optimal days-on-feed based on animals' potential to perform. Stigler (1961) first developed the economics of information, which has since been extended to many agricultural settings, including the value of genetic information in livestock production (e.g., Ladd and Gibson, 1978). The value of information is calculated as "the difference between expected returns (or utility) using the information and expected returns without the information, with both expectations taken with respect to the more informed distribution" (Babcock, 1990, p.63).

Data

Data for 10,209 commercially-fed cattle from six different Midwestern feed yards were provided by Neogen, the parent company of commercial testing service Igenity. Cattle represented year-round placements in the years 2007 and 2008. At placement, animals were weighed and a hair sample or tissue punch from ear tag application was collected for genetic testing. Genetic information was provided in the form of molecular breeding values (MBVs) for the following seven traits: yield grade, marbling, average daily gain (lbs./day), hot-carcass weight (lbs.), rib-eye area (in^2), tenderness (lbs. of Warner-Bratzler shear force [WBSF]), and days-on-feed (days) (Igenity, 2013). Molecular breeding values are a continuous representation of an animal's genetic potential to express a given trait. Similar to expected progeny differences (EPDs), MBVs are reported in the units of the trait they represent. However, they are interpreted as the “relative differences expected in animals across breeds compared to their contemporaries” (Igenity, 2013, p. 2). For example, if two animals exposed to the same environmental and management conditions have marbling MBVs of -100 and 100, respectively, we would expect, on average, that these two animals’ marbling scores would differ by 200 units (100 - [-100] = 200). Additional live animal characteristics for days-on-feed, sex, and hide color were also provided, and carcass measurements for calculated yield grade, marbling score, and hot-carcass weight were collected at slaughter.

After deleting observations with missing data for live animal characteristics and MBVs there were 9,465 observations. The data consisted of seven “sets” each of which represented a different commercial feedlot, time period, or both. Nested within each set were contemporary groups which were groups of animals that had an equal opportunity to perform: same sex, managed alike, and exposed to the same feed resources. A total of 242 contemporary groups had an average size of 39 animals per group.

Additional missing data were common for growth and carcass performance variables. Average daily gain, calculated yield grade, and marbling score had 1,795, 25, and 421 missing observations, respectively, and there were 3,692 missing observations for final live weight. Although final live weight was not used directly, it was essential to the estimation of dressing percentage (dressing percentage = hot-carcass weight/final live weight). Observations with missing data for these growth and carcass performance variables were not deleted from the sample. Instead, regression equations characterizing these outcomes were estimated with their own maximum number of observations. Subsequent simulation analyses used the sample of 9,465 complete observations for live animal characteristics and MBVs. Summary statistics for growth and carcass performance, live animal characteristics, and MBVs are reported in Table 1.

A joint distribution of observed yield and quality grade outcomes for the cattle in our sample is reported in Table 2. The majority of cattle graded either yield grade 2 (44%) or 3 (37%) and quality grade Choice (54%) or Select (42%), and the single most likely outcome is yield grade 3, Choice (24%). This distribution is similar to the distribution of yield grade and quality grade outcomes reported in the 2011 NBQA, which represented 7,941 animals from 28 federally inspected beef processing facilities throughout the United States (Moore et al., 2012, p. 5146). Therefore, our sample is representative of the current distribution of carcass quality in the U.S. beef industry.

Many seasonal patterns exist in cattle markets. In particular, the seasonal relationship between live weight and dressed weight prices caused the results to be sensitive to weekly price fluctuations throughout the year (Figure 1). This relationship is partially attributable to seasonal supply factors. For example, total marketings increase each year during the months of May-July. In addition, regional marketings of Midwestern cattle also increase relative to marketings of cattle in the Southern Plains during this same period. Therefore, a simple average of weekly prices for the 2014 marketing year was used to avoid seasonal fluctuations in live weight and dressed weight prices. Weekly prices were obtained from Livestock Marketing Information Center (LMIC) spreadsheets that are based on USDA Agricultural Marketing Service (AMS) reports (LMIC, 2015). Live weight and dressed weight prices for steers and heifers were obtained from the *5 Area Weekly Weighted Average Direct Slaughter Cattle Report*, LM_CT150 (USDA AMS, 2015a), and grid premiums and discounts were from the *5 Area Weekly Weighted Average Direct Slaughter Cattle Report – Premiums and Discounts*, LM_CT169 (USDA AMS, 2015b) (Table 3). Actual final live weight and hot-carcass weight outcomes were calibrated by imposing market efficiency on the live weight and dressed weight pricing scenarios by adjusting pencil shrink.[1]

In addition to live weight and dressed weight prices, the Choice-Select spread also follows a seasonal pattern (Fausti and Qasmi, 2002). Therefore, two additional grids representing the weeks with the maximum (September 22, 2014) and minimum (February 2, 2014) Choice-Select spread for 2014 were also evaluated to determine the sensitivity of our results to seasonal changes in the grid (Table 3).

Feed costs were also needed to calculate expected profit. Given that observations of feed intake were unavailable, a dry matter intake (DMI) model was used following the National Research Council's (NRC) *Nutrient Requirements of Beef Cattle* (NRC, 2000).[2] The DMI model generates an estimate of "standardized" feed intake. Much like holding prices constant, this approach places all animals on a level playing field in order to estimate an expected value of genetic information. Additional information needed to estimate expected profit includes dry matter cost of $230/ton ($0.12/lb.), yardage cost of $0.40/day, a 7% interest rate on the purchase of feeder cattle, and a mortality rate of 1% (Lardy, 2013).

Procedures

Predicting Growth and Carcass Performance Using Genetics

Mixed model regression equations characterizing phenotypic outcomes for average daily gain (AGD), dressing percentage (DP), yield grade (YG), and quality grade (QG) were estimated

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[1] It is unknown how or when animals were weighed, or if all animals were treated the same. Therefore, this "calibration" allows us to adjust the relationship between live weight and dressed weight pricing using pencil shrink to impose the reasonable assumption of market efficiency.

[2] For examples of the dry matter intake model see Lusk (2007) or Thompson et al. (2014).

independently using restricted maximum likelihood (REML). Dependent variables in each of the four equations were continuous. In particular, YG and QG are often thought of in terms of discrete outcomes. However, calculated yield grade, as defined by the USDA AMS, is a continuous function of backfat, kidney, pelvic, and heart fat, hot-carcass weight, and rib-eye area (USDA AMS, 1997), and marbling score was used as a continuous representation of quality grade. Marbling scores between 200-299 are said to have traces of intramuscular fat and are graded Standard, 300-399 are Select, 400-699 are Choice, and scores over 700 are Prime (USDA AMS, 1997, 2006). The models were specified as

$$(5)\quad Y_{ijkl} = \beta_{0l} + PWT_{ijk}\beta_{1l} + DOF_{ijk}\beta_{2l} + DOF_{ijk}^2\beta_{3l} + PWT_{ijk}DOF_{ijk}\beta_{4l} + STR_{ijk}\beta_{5l} + BLK_{ijk}\beta_{6l} + \sum_{m=1}^{7} MBV_{ijkm}\beta_{7lm} + v_{jl} + u_{k(j)l} + \varepsilon_{ijkl},$$

were Y_{ijkl} is the dependent variable for the ith animal in the jth set and kth contemporary group for the lth equation, where l = 1, 2, 3, or 4 for ADG_{ijk}, DP_{ijk}, YG_{ijk}, and QG_{ijk}, respectively. The model included fixed effects for live animal characteristics and genetic information, where PWT_{ijk} is placement weight, DOF_{ijk} is days-on-feed, STR_{ijk} is a dummy variable equal to 1 if the animal was a steer and 0 otherwise, BLK_{ijk} is a dummy variable equal to 1 if the animal had black hide and 0 otherwise, and MBV_{ijkm} are the seven MBVs characterizing yield grade, marbling, average daily gain, hot-carcass weight, rib-eye area, tenderness, and days-on-feed. Set random effects, $v_{jl} \sim N(0, \sigma_v^2)$, contemporary group random effects nested within sets (Greene, 2012), $u_{k(j)l} \sim N(0, \sigma_u^2)$, and a random error term $\varepsilon_{ijkl} \sim N(0, \sigma_\varepsilon^2)$ are also included in each equation. Yield grade MBV by days-on-feed and marbling MBV by days-on-feed interaction terms are also included as slope shifters in the YG and QG equations. In addition, a yield grade MBV by marbling MBV interaction is also included in the YG and QG equations to account for the positive phenotypic and genetic correlation between these two carcass traits (DeVuyst et al., 2011; Thompson et al., 2015).

Models were estimated independently using Proc Mixed in SAS (SAS Institute Inc., 2013). D'Agostino-Pearson K^2 omnibus test for skewness and kurtosis and a conditional variance test identified evidence of nonnormality and static heteroskedasticity. Sandwich estimators of the standard errors were estimated to obtain estimates of standard errors that were consistent in the presence of nonnormality and static heteroskedasticity (White, 1982). Given the large sample size, asymptotic properties are relevant, and the small sample biases common with generalized method of moments estimators should be of little concern.

Expected Profit Maximization for Alternative Marketing Scenarios

Baseline Marketing Scenarios

To determine the value of genetic information for improving fed cattle marketing decisions, three baseline marketing scenarios were created in which all cattle were marketed in a single group on a live weight, dressed weight, or grid basis. Assuming risk neutrality, expected profit in equation (1) is nonlinear. Therefore, because of Jensen's inequality, profit calculated at the expected value of prediction equations will not equal expected profit (Greene, 2012). For this reason, the integral in equation (1) was evaluated using Monte Carlo integration. The Cholesky decomposition of the four-by-four variance-covariance matrix of the error terms in equation (7) was calculated and used to generate a multivariate normal distribution of 200 error terms for each of the four prediction equations for each animal in the sample (n = 9,465) using "intelligent," quasi-random Halton draws (Morokoff and Caflisch, 1995; Greene, 2012). Profit was evaluated at each draw using observed MBVs for each animal in the sample, and the average across animals was expected profit. This process was repeated for days-on-feed from 100-200 days, and a grid search was used to determine the day at which expected profit was maximized for each of the three marketing scenarios. Live animal characteristics other than MBVs may also influence fed cattle marketing decisions. In particular, placement weight has a substantial impact on how long cattle are fed, how they are marketed, and, as a result, profitability. For this reason, placement weight was held constant at its mean value (700 lbs.) to separate this effect from the effect of genetic information.

Genetic Information Marketing Scenario

Baseline scenarios were compared with alternative marketing scenarios in which additional information was used to enhance fed cattle marketing decisions. The genetic information marketing scenario used the results of genetic testing to sort cattle into marketing groups based on their expected performance. A random sample of 1,000 animals was used to develop a "decision rule" characterizing the relationship between expected profit for each of the three marketing methods and MBVs for yield grade and marbling. Twenty discrete values for the yield grade and marbling MBVs were chosen to represent the range of MBVs observed in our sample, and a Monte Carlo integration procedure similar to the one described above was then used to estimate expected profit for each unique combination of these values (400 times). Plotting the results on a three dimensional surface defined a decision rule that identified which of the three marketing methods generated the highest expected profit at various levels of genetic potential for yield grade and marbling.

Applying this decision rule to the data, the full sample of animals (n = 9,465) was sorted into three marketing groups (live weight, dressed weight, or grid pricing) based on their actual yield grade and marbling MBVs. Monte Carlo integration was used to estimate expected profit for each group for days-on-feed from 100-200 days, and a grid search was used to determine the day at which expected profit was maximized for each group. Overall expected profit was calculated as the weighted average expected profit across the three groups, where the proportion of cattle that fell into each group was used as the weight.

Perfect Information Marketing Scenario

While genetic information can be used to improve predictions of animal performance in the feedlot, it is not 100% accurate.[3] Therefore, we evaluated the potential of genetic testing by estimating a "perfect information" marketing scenario. This was identical to the genetic information marketing scenario described above, except that instead of sorting animals based on genetic information, each animal was sorted into the marketing group that maximized its own expected profit.

Expected Utility Maximization for Alternative Marketing Scenarios

Given the risk-return tradeoff associated with fed cattle marketing, it was also important to consider how decision makers' risk preferences affect their marketing decisions. Therefore, expected utility of profit was estimated for the three baseline marketing scenarios, the genetic information marketing scenario, and the perfect information marketing scenario using similar procedures to those described above. Distributions of profit were converted to utility assuming a negative exponential utility function (Chavas, 2004), $U(\pi) = -e^{-r\pi}$, where $U(\pi)$ is the utility of profit and r is the Arrow-Pratt absolute risk aversion coefficient. A range of risk aversion coefficients were evaluated, and following Raskin and Cochran (1986) and Anderson and Dillon (1992) risk aversion coefficients of $r = 0.0005$, $r = 0.002$, and $r = 0.004$ were determined to approximately represent slight, moderate, and severe risk aversion, respectively.

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[3] For further discussion of the accuracy of genetic marker panels see Weber et al. (2012) and Akanno et al. (2014).

The marketing scenario with the highest expected utility can be identified as the preferred marketing strategy for a given level of risk aversion. However, these values offer little insight into the value of information for sorting and selectively marketing cattle. For this reason, expected utilities of profit were converted to certainty equivalents, which represent the amount of money ($/head) a producer would have to receive to be indifferent between that payoff and a given gamble (Chavas, 2004). Therefore, the difference in certainty equivalents for alternative marketing scenarios and the three baseline marketing scenarios for a given level of risk aversion can be interpreted as the value information inclusive of risk preferences.

Results and Discussion

Regression Equations

Estimates for mixed model regression equations are reported in Table 4. Each equation was estimated with its own maximum number of observations. Coefficients for live-animal characteristics, including placement weight, days-on-feed, sex, and hide color, generally exhibited the expected relationships in each equation.

Molecular breeding values influenced corresponding growth and carcass performance variables in the expected directions. For example, the average daily gain MBV had a significant, positive effect in the average daily gain equation, indicating that higher genetic potential for average daily gain resulted in higher actual average daily gain. The relative interpretation of MBVs implies a linear relationship with a coefficient of one between MBVs and the traits they characterize (Weber et al., 2012). Therefore, we tested the null hypothesis that the marginal effect of the average daily gain MBV was equal to one, $H_0: \partial ADG / \partial MBV_{ADG} = 1$. Results indicated that the observed marginal effect, 0.757, was not statistically different from one (t = -0.79; df = 7,437; P = 0.43).

The hot-carcass weight MBV had a significant, positive effect on dressing percentage outcomes. This result was consistent with expectations given the relationship between these two characteristics. However, because this MBV does not directly reflect genetic potential for dressing percentage, we were unable to test the hypothesis that this effect was equal to one.

Due to interaction terms, the marginal effect of the yield grade MBV on yield grade outcomes was a function of days-on-feed and marbling MBV: $\partial YG/\partial MBV_{YG} = -0.382 - 0.002 \times DOF + 0.009 \times MBV_{MARB}$. Therefore, the test of the null hypothesis that this marginal effect was equal to negative one, $H_0{:}\, \partial YG/\partial MBV_{YG} = -1$,[4] was conducted at the mean value of days-on-feed (176 days) and marbling MBV (-21.661). At these values, the marginal effect was approximately -0.929, and we failed to reject the null hypothesis that this value was negative one (*t* = 0.46; df = 9,169; *P* = 0.65).

Similarly, the marginal effect of the marbling MBV on quality grade outcomes was a function of days-on-feed and yield grade MBV: $\partial QG/\partial MBV_{MARB} = -0.148 + 0.005 \times DOF - 0.170 \times MBV_{YG}$. Therefore, the test of the null hypothesis that this marginal effect equals one, $H_0{:}\, \partial QG/\partial MBV_{MARB} = 1$, was conducted at the mean value of days-on-feed (176 days) and yield grade MBV (-0.054). At these values, the marginal effect was approximately 0.741, and we rejected the null hypothesis that this value was one (*t* = -4.45; df = 8,779; *P* < 0.01). This was consistent with the finding that MBVs underestimate the expected change in phenotypic outcomes relative to a change in MBVs (Weber et al., 2012). Despite advancements in the procedures for estimating MBVs, their accuracy still depends on the persistency of linkage disequilibrium between single nucleotide polymorphisms (SNP) and quantitative trait loci (QTL)

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[4] The marginal effect of the yield grade MBV on yield grade outcomes had an expected value of negative one because lower yield grade outcomes are more favorable.

and the relationship between training and target populations (Akanno et al., 2014). Therefore, it was not surprising that this effect shrunk towards zero when the MBV procedure was applied to new data. Nevertheless, the marginal effect of the marbling MBV was still statistically different from zero ($t = 11.05$; df = 8,779; $P < 0.01$), indicating that higher genetic potential for marbling resulted in more favorable quality grade outcomes.

Expected Profit for Alternative Marketing Scenarios

Baseline Marketing Scenarios

For the set of animals used in this analysis and average 2014 prices, maximum expected profit for the three baseline scenarios in which all animals were marketed in a single group on a live weight, dressed weight, or grid basis was -\$19.15, -\$18.25,[5] and -\$12.03/head, respectively (Table 5). The finding that grid pricing generated the highest returns was consistent with Anderson and Zeuli (2001) and Walburger and Crews (2004). However, live weight and dressed weight pricing have also been found to generate the highest returns in other studies (Feuz, Fausti, and Wagner, 1993; Fausti, Feuz, and Wagner, 1998; Schroeder and Graff, 2000; Lusk et al., 2003). As previously discussed, the marketing method that generated the highest returns depends on prices and quality characteristics of the cattle used in each study. Given the large, representative sample of cattle used in this study, the finding that grid pricing generated the highest returns suggests that the market has already started to adjust to higher quality animals being targeted towards grid pricing. This is consistent with Fausti et al. (2014) who found that

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[5] Calibration of live weight and dressed weight baseline marketing scenarios to market efficiency was conducted using actual final live weights and hot-carcass weights. Therefore, when applied to simulation analyses values of expected profit for live weight and dressed weight marketing scenarios differed slightly due to differences in optimal days-on-feed.

the grid premium and discount structure is adjusting market signals to encourage producers to market on a grid and discourage live weight and dressed weight pricing.

Although grid pricing generated the highest expected profit per head, it also had the highest standard deviation ($33.49). This result was consistent with the findings of previous research (Feuz, Fausti, and Wagner, 1993; Schroeder and Graff, 2000; Anderson and Zeuli, 2001; Fausti and Qasmi, 2002; Lusk et al., 2003), and has been identified as the primary barrier to the adoption of grid pricing (Fausti, Feuz, and Wagner, 1998; Anderson and Zeuli, 2001; Fausti and Qasmi, 2002).

Genetic Information Marketing Scenario

The decision rule indicated that animals with higher genetic potential for marbling should be marketed on a grid, and animals with lower genetic potential for marbling should be marketed using either live weight or dressed weight pricing (Figure 2). At lower levels of genetic potential for marbling, dressed weight pricing was preferred for animals with lower yield grade MBVs, and live weight pricing was preferred for animals with higher yield grade MBVs. This result was likely explained by the negative effect of the yield grade MBV in the dressing percentage regression equation (Table 4). That is, animals with higher genetic potential for yield grade tended to have lower dressing percentages. Although this effect was not statistically significant, it was economically important for producers making marketing decisions.

Applying this decision rule to the data, 10% of cattle were targeted to live weight pricing, 17% to dressed weight pricing, and 73% to grid pricing (Table 5). Investigation of the outcomes for individual marketing groups indicated that expected profit for live weight (-$41.33/head) and dressed weight (-$35.24/head) pricing decreased relative to their respective baseline scenarios, but expected profit for grid pricing increased to -$0.71/head. Therefore, the ability to identify animals that will perform poorly at slaughter and pull them off of the grid increased expected profit for grid pricing by more than $11/head. As a result, overall expected profit for the genetic information marketing scenario increased to -$10.64/head. Comparing this value with expected profit for the grid baseline marketing scenario, the expected value of genetic information for a producer currently marketing cattle in a single group using grid pricing was $1.39/head (-$10.64 - [-$12.03] = $1.39) (Table 8). While this value was relatively low, it is important to remember that few producers currently market all of their cattle on the grid as a result of higher variability. Therefore, the value of genetic information for producers currently using live weight or dressed weight pricing was $8.51 and $7.61/head, respectively.

In addition to improvements in expected profit, using genetic information to sort cattle into marketing groups also resulted in efficiency gains to cattle feeding. For example, relative to their respective baseline scenarios, optimal days-on-feed decreased for live weight (147 days) and dressed weight (177 days) pricing and increased for grid pricing (182 days) (Table 5). Given that 25% of animals in the feedlot are overfed and 25% are underfed (Brethour, 2000), this indicated that when sorted and targeted to their optimal marketing method, animals with lower genetic potential for marbling could be fed for fewer days, and animals with higher genetic potential for marbling could be fed slightly longer to achieve more favorable quality grade outcomes.

Furthermore, the standard deviation of expected profit for all three marketing groups decreased relative to the standard deviations in their respective baseline scenarios. This is particularly important given that one of the primary motivations for sorting cattle into marketing groups was to reduce the variability among animals treated alike (Fausti, Wang, and Lange, 2013). More importantly, the standard deviation of overall expected profit for the genetic information marketing scenario ($31.42) was less than the grid baseline marketing scenario ($33.49). Therefore, in addition to improving the returns to cattle feeding, genetic sorting can also reduce the variability, or risk, associated with selling fed cattle.

Sensitivity analysis was conducted using the grids associated with the maximum and minimum weekly Choice-Select spread for 2014. As expected, the decision rule for the maximum grid was similar to Figure 2, with a lower marbling MBV threshold, indicating that a slightly larger portion of cattle were targeted to the grid (74%) (Table 6). The decision rule for the minimum grid was also similar to Figure 2, with a slightly higher (lower) marbling MBV threshold at lower (higher) levels of genetic potential for yield grade. Contrary to expectations, when this decision rule was applied to the data the portion of cattle targeted to the grid actually increased (77%) (Table 7). The lower Choice-Select spread made yield grade outcomes more economically important relative to quality grade outcomes, and, as a result, animals with higher yield grade MBVs were more likely to be targeted to the grid regardless of their genetic potential for marbling.

Other notable results for the maximum (Table 6) and minimum (Table 7) grid scenarios were qualitatively similar to the average pricing scenario described above. However, the values of genetic information for the maximum grid increased for each of the three baseline marketing scenarios and ranged from $2.51 to $12.35/head depending on how a producer currently markets cattle (Table 8). Conversely, the values of genetic information for the minimum grid decreased and ranged from just $0.62 to $4.62/head.

Perfect Information Marketing Scenario

For the set of animals and prices used, perfect information dictated that 20% of cattle be targeted to live weight pricing, 18% to dressed weight pricing, and 62% to grid pricing (Table 5).

While grid pricing still accounted for the majority of marketings, it made up a considerably lower percentage of total marketings than indicated by the yield grade and marbling MBV decision rule described above. Nevertheless, overall expected profit for the perfect information marketing scenario increased to -$8.09/head and the standard deviation decreased ($30.85), indicating that more accurate sorting could further increase returns and further decrease the variability associated with cattle feeding. As a result, values of perfect information were consistently higher than the values of genetic information and ranged from $3.94 to $14.11/head depending on how a producer currently markets cattle and which grid was used (Table 8).

Expected Utility for Alterative Marketing Scenarios

Incorporating risk preferences into the model indicated that slight risk aversion generated qualitatively similar results to the risk neutral scenario described above (Table 9). However, as risk aversion increased, decision maker's preferences shifted away from grid pricing towards less risky live weight pricing. For example, certainty equivalents identified live weight pricing as the preferred baseline marketing method for moderate (-$36.45/head) and severe (-$52.69/head) risk aversion, and genetic information and perfect information marketing scenarios targeted fewer animals to the grid and more animals to live weight pricing as risk aversion increased. In addition to the shift in preferences for live weight and grid marketing methods, results also indicated that risk-averse decision makers marketed animals earlier (decreased optimal days-on-feed) to reduce the variability of profit and thus maximize expected utility, which was consistent with the findings of Lambert (2008).

Despite differences in optimal marketing strategies and optimal days-on-feed, the range of values of genetic and perfect information for sorting and selectively marketing cattle was largely unchanged when risk was considered (Table 10). Instead, as risk aversion increased, values of information for producers currently using live weight pricing to market cattle decreased and values of information for producers using dressed weight and grid pricing increased. This complementary effect was the product of the shift in preferences for marketing methods from grid pricing to live weight pricing described above. As risk aversion increased and live weight pricing became more preferred relative to the other marketing methods, the value of being able to sort and selectively market cattle diminished for producers already using live weight pricing and increased for those using dressed weight or grid pricing. This result is consistent with Lambert (2008) who found that certainty equivalents fell as risk aversion increased, but the differences in certainty equivalents among cattle with different leptin genotypes did not change significantly. Therefore, our results indicate that while risk aversion is important for understanding how producers market cattle, it did not have a substantial impact on the value of genetic information.

Conclusions

This study examined the value of genetic information for improving fed cattle marketing decisions. Results indicated that using genetic information characterizing yield grade and marbling to sort cattle into marketing groups to be targeted to different marketing methods (live weight, dressed weight, or gird pricing) and to determine the optimal marketing date (days-on-feed) for each group increased expected profit by $1 to $8/head depending on how a producer currently markets cattle. We also evaluated the potential of genetic testing by sorting cattle based on perfect information. As expected, the perfect information marketing scenario offered slight improvements over genetic information. Sensitivity analysis indicated that values of information were influenced by variations in the grid, which are mainly driven by the seasonality of the Choice-Select spread (Fausti and Qasmi, 2002). Depending on when cattle were marketed, values of information ranged from less than $1 to $12/head for genetic information, and from $4 to $14/head for perfect information.

Given the risk-return tradeoff associated with fed cattle marketing, it was also important to consider how decision makers' risk preferences affect their marketing decisions. Despite differences in optimal marketing strategies and optimal days-on-feed, the range of values of genetic and perfect information was largely unchanged when risk was considered.

Previous research examining the value of genetic information for marker-assisted management has been limited to sorting cattle by optimal days-on-feed (DeVuyst et al., 2007; Lusk, 2007; Thompson et al., 2014). In this study, we extend the definition of marker-assisted management to include a more holistic view of fed cattle marketing, including decisions for marketing method as well as timing to market. As a result, the values of genetic information for marker-assisted management reported in this study were generally higher than those reported in previous research. However, these values were still not enough to offset the cost of genetic testing. Currently, Igenity offers a comprehensive profile of 12 genetic markers for $40/head (Igenity, 2015). In addition to markers characterizing carcass traits, such as yield grade and marbling, this profile also includes markers for maternal traits, docility, growth, feed efficiency, and tenderness. While this comprehensive profile is beneficial for producers using this information to make selection and breeding decisions (Thompson et al., 2014), most of this information is superfluous in the context of managing feedlot cattle. For this reason, commercial testing companies might consider marketing a reduced profile of markers relevant to a particular decision. For example, Igenity currently offers a reduced profile of six traits relevant to the selection of replacement heifers for a cost of $22/head (Igenity, 2015). A similar reduced profile of growth and carcass characteristics may provide the opportunity for cost-effective marker-assisted management of feedlot cattle. In addition, the cost of genetic testing could be further reduced using random sampling to measure the genetic potential of a group of cattle without having to test each animal.

Despite lingering concerns over the economic feasibility of genetic testing, the values of genetic information reported in this study represent meaningful economic value in an industry where average profitability is close to zero. However, it is important to caution the literal use of these values, as the results presented here are conditional on the set of animals and prices used in this analysis. In a real world application, the value of genetic information will depend on relative prices, the quality characteristics of a particular set of cattle, the decision maker's level of information about these characteristics, and the decision maker's risk preferences. In addition, it is also important to note that these values will not persist in the long run. First adopters and owners of the genetic identification technologies will realize profitability gains (Lusk, 2007; Koontz et al., 2008), but eventually selective marketing will signal to buyers that animals marketed on a live weight or dressed weight basis are likely lower quality than animals targeted to the grid. As a result, the market will adjust by decreasing live weight and dressed weight prices relative to grid prices (Schroeder and Graff, 2000; Koontz et al., 2008; Fausti et al., 2014), and the value of information will dissipate. In fact, there is already some evidence of these general equilibrium effects in the fed cattle market (Fausti et al., 2014). There is also the potential for the live weight and dressed weight markets to disappear completely, forcing producers to sell cattle on the grid.

Although improved marketing decisions will increase profitability only in the short run, results also indicated the potential for long-run efficiency gains that will persist because of changes in the product form. Sorting cattle into marketing groups allowed producers to more accurately determine optimal days-on-feed. Animals with lower genetic potential for marbling could be targeted to average pricing mechanisms and fed for a shorter period of time to avoid over-feeding animals that will never achieve quality grade premiums, and animals with higher genetic potential for marbling could be targeted to grid pricing and fed slightly longer in order to achieve more favorable quality grade outcomes. In addition, sorting cattle into marketing groups generally decreased the variability of expected profit. Therefore, the use of genetic testing to selectively market cattle may encourage producers, who might not otherwise do so, to market cattle on a grid (Fausti et al., 2010; Fausti, Wang, and Lange, 2013). This will result in improved quality and consistency of beef products and improved transmission of market signals throughout the beef cattle supply chain, and may help address consumer demand problems.

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Table 1. Summary Statistics for Growth and Carcass Performance, Live-Animal Characteristics, and Molecular Breeding Values

Variable	*n*	Mean	Standard Deviation	Minimum	Maximum
Growth and carcass performance					
Average daily gain, lbs/day	7,670	3.390	0.803	-14.056	7.383
Dressing percentage	5,773	0.627	0.028	0.490	0.827
Yield grade	9,440	2.704	0.853	0.056	5.905
Marbling score[a]	9,044	416.3	79.5	190.0	830.0
Live animal characteristics					
Placement weight, cwt[a]	9,465	7.0	1.2	2.9	11.2
Days-on-feed, days[a]	9,465	176.0	35.4	81.0	308.0
Steer	9,465	0.826			
Black	9,465	0.623			
Molecular breeding values (MBV)					
Yield grade MBV	9,465	-0.054	0.073	-0.338	0.210
Marbling MBV	9,465	-21.661	28.017	-124.020	76.353
Average daily gain MBV, lbs./day	9,465	0.168	0.100	-0.229	0.482
Hot-carcass weight MBV, lbs.	9,465	27.231	8.969	-17.728	55.913
Rib-eye area MBV, in^2	9,465	-0.572	0.523	-2.172	1.588
Tenderness MBV, lbs. of WBSF[b]	9,465	-0.991	1.348	-5.900	2.920
Days-on-feed MBV, days	9,465	-2.628	2.811	-14.351	9.160

Notes: Molecular breeding values (MBVs) are reported in the units of the trait, and reflect the differences expected in animals across breeds compared to their contemporaries (Igenity, 2013). Therefore, mean MBVs offer little insight. Instead, the range of MBVs is more informative. For example, the range of average daily gain MBVs suggests that the animal with the highest genetic potential for average daily gain in the sample would be expected, on average, to gain approximately 0.71 lbs. per day more than the animal with the lowest genetic potential for average daily gain (0.482 - [-0.229] = 0.711).

[a] Summary statistics for marbling score, placement weight, and days-on-feed are only reported to one decimal place as a result of significant digits.

[b] Warner-Bratzler shear force.

Table 2. Joint Distribution of Observed Yield and Quality Grade Outcomes (*n* = 9,029)

	USDA Quality Grade				
USDA Yield Grade	Prime	Choice	Select	Standard	Total
1	<1%	5%	8%	1%	14%
2	<1%	20%	21%	1%	44%
3	<1%	24%	12%	<1%	37%
4	<1%	4%	1%	<1%	5%
5	0%	<1%	<1%	<1%	<1%
Total	<1%	54%	42%	3%	100%

Table 3. Live Weight Prices, Dressed Weight Prices, and Grid Premiums and Discounts for 2014

Marketing Method		Average Prices	Maximum Grid[a]	Minimum Grid[b]
		$/cwt		
Live weight				
Steers		$154.31		
Heifers		$154.44		
Dressed weight				
Steers		$244.22		
Heifers		$244.21		
Grid	Base price[c]			
	Steers	$248.10	$250.78	$245.16
	Heifers	$248.09	$250.77	$245.15
	Quality grade adjustment			
	Prime	$19.26	$21.33	$18.35
	Choice	$0.00	$0.00	$0.00
	Select	($8.63)	($14.57)	($2.09)
	Standard	($20.84)	($23.92)	($17.72)
	Yield grade adjustment			
	1.0-2.0	$4.58	$4.58	$4.58
	2.0-2.5	$2.25	$2.25	$2.24
	2.5-3.0	$2.13	$2.13	$2.11
	3.0-4.0	$0.00	$0.00	$0.00
	4.0-5.0	($8.63)	($8.23)	($9.21)
	>5.0	($13.64)	($13.06)	($14.99)
	Carcass weight adjustment			
	400-500	($25.42)	($25.40)	($25.49)
	500-550	($22.19)	($22.80)	($19.62)
	550-600	($2.93)	($2.70)	($3.89)
	600-900	$0.00	$0.00	$0.00
	900-1000	($0.24)	($0.19)	($0.24)
	1000-1050	($2.27)	($2.22)	($2.35)
	>1050	($23.24)	($23.33)	($23.05)

Source: Livestock Marketing Information Center (LMIC) spreadsheets based on USDA AMS reports LM_CT150 and LM_CT169 (USDA AMS, 2014a; USDA AMS, 2014b; LMIC, 2015).

[a] The "maximum grid" is the grid from the week with the highest Choice-Select spread for 2014 (September 22, 2014).

[b] The "minimum grid" is the grid from the week with the smallest Choice-Select spread for 2014 (February 2, 2014).

[c] The base price for the grid was calculated as the dressed weight price plus the Choice-Select spread times the percent of cattle that graded Select or worse in our data set (Ward, Feuz, and Schroeder, 1999). For example, the base price for the average price grid for steers was: 244.22 + 8.63 × 45% = 248.10.

Table 4. Mixed Model Regression Equations for Average Daily Gain, Dressing Percentage, Yield Grade, and Quality Grade

	Equation			
	ADG	*DP*	*YG*	*QG*
Variable	(*n* = 7,670)	(*n* = 5,773)	(*n* = 9,440)	(*n* = 9,044)
Intercept	1.961	0.340**	1.124	262.200**
Placement weight	0.205	0.010***	0.259***	17.990***
Days-on-feed	0.014*	0.002**	0.002	0.646
Days-on-feed squared	-4.00E-5***	-4.16E-6*	1.40E-5	0.001
Placement weight × days-on-feed	-0.002**	-5.00E-5*	-0.001*	-0.078***
Steer[a]	0.399***	0.004	-0.144***	-34.366***
Black[b]	0.023***	-9.70E-5	0.008	0.583
Yield grade MBV[c]	0.152	-0.007	-0.382	-154.670***
Yield grade MBV × days-on-feed	—	—	-0.002	0.819***
Marbling MBV	0.001	-6.96E-6	0.001	-0.148
Marbling MBV × days-on-feed	—	—	6.77E-6	0.005***
Yield grade MBV × marbling MBV	—	—	0.009***	-0.170
Average daily gain MBV	0.757**	-0.006**	0.028	-0.339
Hot-carcass weight MBV	0.001	1.21E-4***	0.003*	0.176*
Rib-eye area MBV	0.017	0.002	-0.345***	-11.406***
Tenderness MBV	0.002	1.92E-4	0.007	-1.027*
Days-on-feed MBV	-0.001	-2.00E-5	-9.00E-5	-0.266
Random effects[d]				
Set	0.236*	4.99E-4	0.136*	52.483
Contemporary group(Set)	0.101***	2.93E-4***	0.040***	388.960***

Notes: Single, double, and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% levels. Dependent variables in the four equations are average daily gain (ADG), dressing percentage (DP), calculated yield grade (YG), and marbling score (QG).

[a] Steer is a dummy variable equal to one if the animal was a steer and zero otherwise.

[b] Black is a dummy variable equal to one if the animal was black hided and zero otherwise.

[c] Molecular breeding value.

[d] Random effects for set and contemporary groups nested within sets are included in the estimation of each equation (i.e., mixed model regression equations) (Greene, 2012). Sets represent different commercial feedlots, time periods, or both, and contemporary groups are groups of animals that have had an equal opportunity to perform.

Table 5. Expected Profit and Corresponding Optimal Days-on-Feed for Alternative Marketing Scenarios for 2014 Average Prices

Marketing Scenario	Proportion	Optimal Days-on-Feed	Expected Profit	Standard Deviation
			——— $/head ———	
Baseline marketing scenarios				
Market all live weight		151	-$19.15	$27.07
Market all dressed weight		179	-$18.25	$27.09
Market all grid		181	-$12.03	$33.49
Genetic information marketing scenario				
Live weight	10%	147	-$41.33	$23.69
Dressed weight	17%	177	-$35.24	$21.86
Grid	73%	182	-$0.71	$28.28
Weighted average			-$10.64	$31.42
Perfect information marketing scenario				
Live weight	20%	144	-$12.45	$32.28
Dressed weight	18%	179	-$33.93	$21.15
Grid	62%	183	$0.82	$28.08
Weighted average			-$8.09	$30.85

Table 6. Expected Profit and Corresponding Optimal Days-on-Feed for Alternative Marketing Scenarios for the Grid Associated with the Maximum 2014 Choice-Select Spread

Marketing Scenario	Proportion	Optimal Days-on-Feed	Expected Profit	Standard Deviation
			——— $/head ———	
Baseline marketing scenarios				
Market all live weight		151	-$19.15	$27.06
Market all dressed weight		179	-$18.25	$27.09
Market all grid		182	-$9.31	$38.19
Genetic information marketing scenario				
Live weight	10%	147	-$41.33	$23.69
Dressed weight	16%	177	-$35.52	$21.77
Grid	74%	183	$4.08	$31.64
Weighted average			-$6.80	$34.78
Perfect information marketing scenario				
Live weight	15%	144	-$24.27	$29.07
Dressed weight	20%	179	-$34.50	$20.47
Grid	65%	184	$8.45	$29.96
Weighted average			-$5.04	$33.78

Table 7. Expected Profit and Corresponding Optimal Days-on-Feed for Alternative Marketing Scenarios for the Grid Associated with the Minimum 2014 Choice-Select Spread

Marketing Scenario	Proportion	Optimal Days-on-Feed	Expected Profit	Standard Deviation
			——— $/head ———	
Baseline marketing scenarios				
Market all live weight		151	-$19.15	$27.06
Market all dressed weight		179	-$18.25	$27.09
Market all grid		180	-$15.15	$28.81
Genetic information marketing scenario				
Live weight	8%	145	-$43.02	$23.42
Dressed weight	15%	178	-$34.76	$22.20
Grid	77%	181	-$7.63	$25.67
Weighted average			-$14.53	$28.03
Perfect information marketing scenario				
Live weight	23%	145	-$6.21	$33.24
Dressed weight	17%	180	-$26.82	$26.40
Grid	60%	182	-$8.59	$25.59
Weighted average			-$11.14	$28.62

Table 8. Expected Value of Information for Alternative Marketing Scenarios Compared with Baseline Marketing Scenarios for Three Different Grids

	Baseline Marketing Scenarios		
Alternative Marketing Scenarios	Live Weight	Dressed Weight	Grid
	——— $/head ———		
Average grid			
Genetic information	$8.51	$7.61	$1.39
Perfect information	$11.06	$10.16	$3.94
Maximum grid			
Genetic information	$12.35	$11.45	$2.51
Perfect information	$14.11	$13.21	$4.27
Minimum grid			
Genetic information	$4.62	$3.72	$0.62
Perfect information	$8.01	$7.11	$4.01

Table 9. Certainty Equivalents and Corresponding Optimal Days-on-Feed for Alternative Marketing Scenarios for Three Levels of Risk Aversion and 2014 Average Prices

	Slight Risk Aversion ($r = 0.0005$)			Moderate Risk Aversion ($r = 0.002$)			Severe Risk Aversion ($r = 0.004$)		
Marketing Scenario	Proportion	Optimal Days-on-Feed	Certainty Equivalent	Proportion	Optimal Days-on-Feed	Certainty Equivalent	Proportion	Optimal Days-on-Feed	Certainty Equivalent
			$/head			$/head			$/head
Baseline marketing scenarios									
Market all live weight		150	-$23.58		147	-$36.45		142	-$52.69
Market all dressed weight		178	-$24.74		176	-$43.61		172	-$67.51
Market all grid		180	-$19.24		178	-$40.40		174	-$67.58
Genetic information marketing scenario									
Live weight	19%	146	-$42.34	53%	145	-$46.06	86%	142	-$55.76
Dressed weight	8%	177	-$39.92	0%	—	—	0%	—	—
Grid	73%	181	-$7.92	47%	180	-$19.65	14%	177	-$31.90
Weighted average[a]			-$17.08			-$33.82			-$52.56
Perfect information marketing scenario									
Live weight	25%	144	-$20.23	51%	144	-$41.19	83%	142	-$55.83
Dressed weight	17%	178	-$37.22	7%	176	-$43.36	1%	175	-$45.53
Grid	58%	182	-$5.42	42%	181	-$19.34	16%	179	-$30.60
Weighted average[a]			-$14.56			-$32.28			-$51.86

[a] Weighted averages for the genetic information and perfect information marketing scenarios are the certainty equivalents associated with the weighted average expected utility for the three marketing groups, not the weighted average of the certainty equivalents.

Table 10. Expected Value of Information for Alternative Marketing Scenarios Compared with Baseline Marketing Scenarios for Three Levels of Risk Aversion and 2014 Average Prices

	Baseline Marketing Scenarios		
Risk Aversion	Live Weight	Dressed Weight	Grid
		$/head	
Slight risk aversion			
Genetic information	$6.50	$7.66	$2.16
Perfect information	$9.02	$10.18	$4.68
Moderate Risk Aversion			
Genetic information	$2.63	$9.79	$6.58
Perfect information	$4.17	$11.33	$8.12
Severe risk aversion			
Genetic information	$0.13	$14.95	$15.02
Perfect information	$0.83	$15.65	$15.72

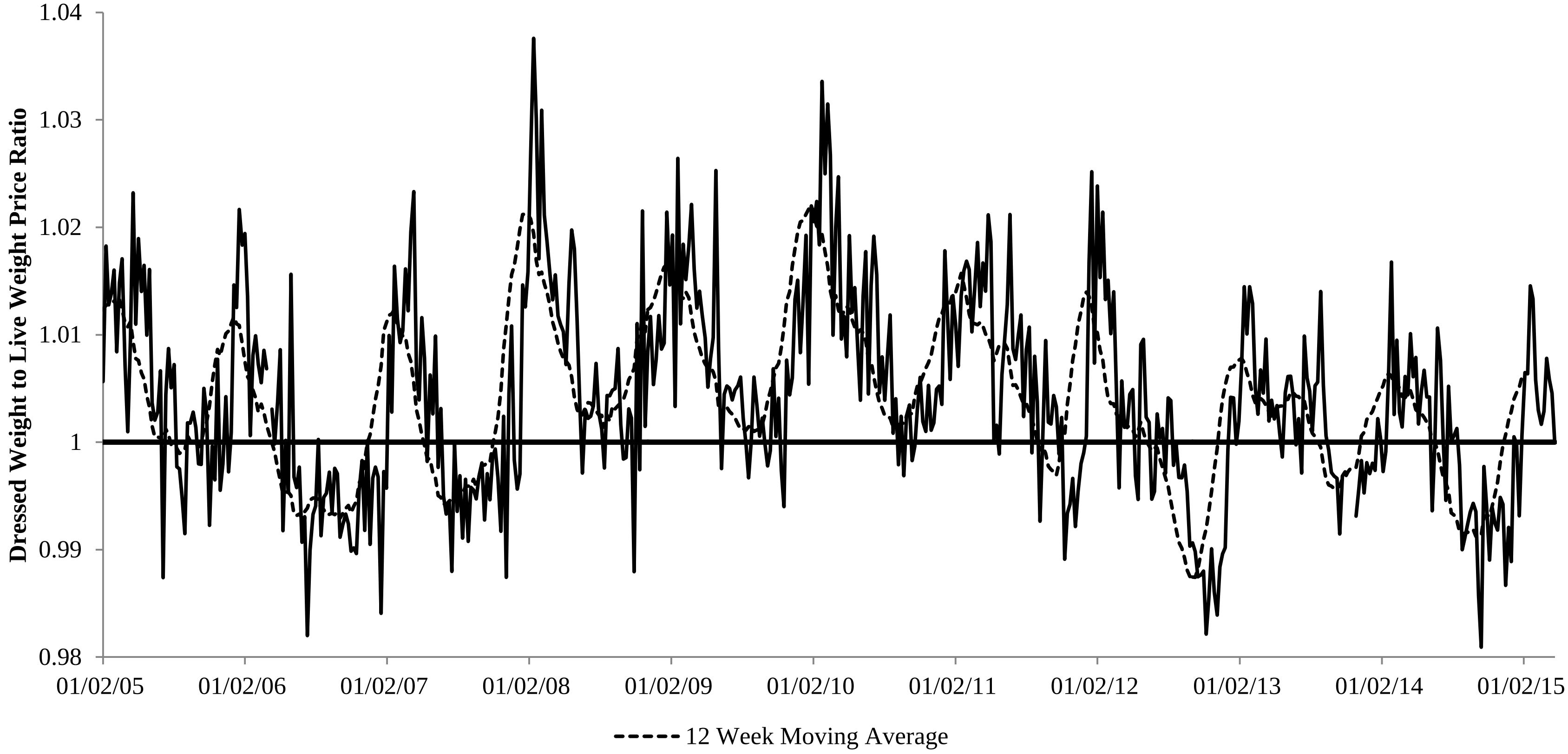

Figure 1. Weekly Dressed Weight to Live Weight Price Ratio, 2005-2015

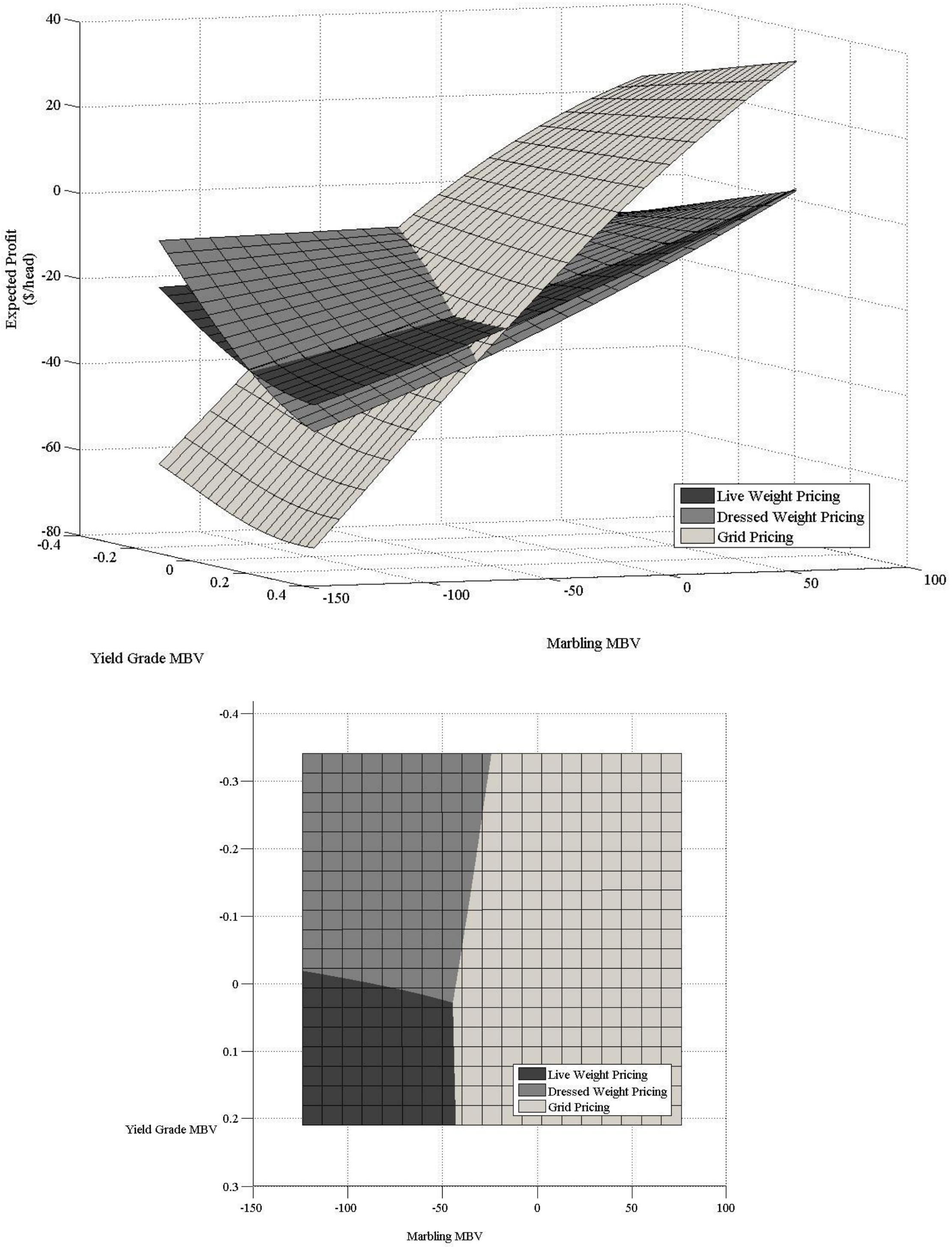

Figure 2. Three-Dimensional Surface and Corresponding Contour Plot of the Fed Cattle Marketing Decision Rule Using Molecular Breeding Values (MBV) Characterizing Yield Grade and Marbling for 2014 Average Prices