AN ECONOMIC ANALYSIS OF FED CATTLE MARKETING USING REAL-TIME ULTRASOUND

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Title

AN ECONOMIC ANALYSIS OF FED CATTLE MARKETING USING

REAL-TIME ULTRASOUND TECHNOLOGY

By

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MASTER OF SCIENCE

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ABSTRACT

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Live measurements of backfat thickness and ribeye area can aid feedlot operators to market cattle more efficiently by assessing carcass traits before slaughter. In this study, ultrasound information is investigated as a potential tool to improve marketing decisions and feedlot profit. Live and carcass measurements made on 180 cross-bred cattle fed in Britton, South Dakota, in 2003-2004, were used to project carcass traits employing regression models. Simulation optimization models were used to determine the length of feeding period that maximizes feedlot returns to ultrasound, given alternative sets of information, price grids and marketing constraints. A comparative economic analysis was made between average returns resulting from the inclusion of one or two live ultrasound measurements.

As in previous studies, the results indicate that the net feedlot profit may be increased using ultrasound technology in marketing decisions. When one ultrasound measurement, taken early in the feeding period, is employed, average return increased by $16.03/head in comparison to actual marketing, considering costs relative to ultrasound measurements. The comparison increased to $16.18/head when a late finishing period measurement is considered. When both measurements are employed, the computed average return is $17.49/head. Given a cost of $8/head relative to ultrasound measurements, it is advisable to employ one ultrasound measurement.

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INTRODUCTION

Grid pricing of fed cattle offers producers opportunities to improve profitability by finishing cattle to achieve premiums and avoid discounts (Greer and Trapp, 2000; Lusk et al., 2003). However, to most profitably market cattle under grid pricing, producers need more information regarding carcass quality than under alternative pricing systems. Lusk et al. and Koontz et al. (2000) investigated the use of real-time ultrasound (RTU) measurements to improve predictions of carcass quality and producer profits. This study also investigates RTU and producer profits. Where Lusk et al. considered RTU measurements taken before the finishing period and Koontz et al. considered measurements taken approximately 90 days prior to marketing, this study considers using two RTU measurements. These measurements were taken at placement in feedlot and approximately three weeks prior to marketing.

Individual cattle price is derived from hot carcass weight (HCW), yield grade, and quality grade (USDA, 1997). HCW is the weight after hide, head, viscera and extremities have been removed from carcass. Yield is “the percentage of boneless and closely trimmed retail cuts from the wholesale cuts” (USDA, 1997, pg. 5) and is a function of hot carcass weight (HCW); backfat thickness (BF); ribeye area (REA) and kidney, pelvic and heart fat (KPH). Yield is divided into five grades, 1 through 5, with Yield Grade 1 denoting the “highest degree of cutability” (USDA, 1997, pg. 6).

Quality grade is determined by marbling score (MS) and is defined as “characteristics of the meat that predict the palatability of the lean” (USDA, 1997, pg. 5). Fed cattle usually reach one of the four highest quality grades: Prime, Choice, Select or Standard. Of the four, Prime is used to designate carcasses with the highest degree of marbling, and Standard designates the lowest degree of marbling. Under many grid pricing formulas, Choice grade is further divided into low Choice, denoting the lower one-third of Choice grade, and high Choice, denoting the upper two-thirds of Choice grade.

Since marbling is a measure of fat content, an increase in marbling score generally leads to a decrease in leanness and an increase in yield grade (Brethour, 2000). Consequently, the management challenge is to choose the days-on-feed that strikes an economic balance between yield and quality grades, leading to marbling but avoiding over-finished animals.

RTU provides a means of measuring backfat thickness, ribeye area and marbling in live animals. This information can be used to predict carcass characteristics at varying marketing dates so RTU may provide economic benefits to feedlot managers. Basarab et al. (1999), Koontz et al. (2000), Lusk et al. (2003) report improved profitability when RTU-based projections of carcass characteristics are used to aid in fed cattle marketing decisions.

This study tests the hypothesis that feedlot profits can be improved by using predictors of carcass yield derived from RTU measurements of backfat and ribeye area. Regression models are estimated and used to predict carcass traits for varying days-on-feed and given alternative information sets. Information sets include 1) visual characteristics and live weights; 2) live weights and RTU measurements at weaning; 3) live weights and RTU measurements taken three weeks prior to expected marketing date; and 4) live weights and RTU measurements taken at weaning and three weeks prior to expected marketing date. Returns are computed using the predicted carcass characteristics for various days-on-feed. The days-on-feed that maximize returns to RTU are determined for each information set. Finally, maximized returns are determined under each of the information sets. Statistical tests are used to evaluate differences in maximized returns and profits of the various information sets.

LITERATURE REVIEW

Ultrasound technology

At the feedlot, ultrasound measurements can be used to sort, select and market cattle considering their individual performance. RTU accuracy, repeatability and predictability were assessed by Brethour (1992), Greiner et al. (2003), Houghton and Turlington (1992) and May et al. (2000). Results indicate that RTU technology can predict carcass traits before marketing decisions. Using these predictors, feedlot operators can adapt their management to achieve target end-points (Williams, 2002; Lusk et al., 2003).

Haughton and Turlington (1992) reviewed the use of RTU technology for prediction of carcass traits. They conclude that live ultrasound can accurately predict backfat and ribeye area. However, regarding marbling, they conclude that its prediction "remains unclear and requires further investigation."

Brethour (2000) investigated the potential of serial ultrasound to predict days-on-feed to reach a target carcass backfat value and to project carcass-marbling score. Ultrasound can predict the marketing date that will reach a target carcass backfat value with an average error of 30 days, depending on the date of the measurement. Ultrasound can also be used to project marbling score with accuracy improving the closer the measurement date is to the slaughter day. Brethour's analysis indicates that the prediction of the classifying quality grade Choice/Select is 76% accurate using ultrasounds made 12 days before slaughter on a group of 137 continental breed steers.

Potential economic benefit of RTU

Few studies (Basarab et al., 1999; Koontz et al., 2000; Lusk et al., 2003) focused on the economic value of the use of ultrasound to manage cattle. Their results indicate that practical applications of ultrasound could increase feedlot profits. Williams (2002) argues that there is "great potential of ultrasounds to return substantial net income on a per animal basis in the beef industry."

Basarab et al. (1999) investigated the Kansas State University (KSU) sorting system. This system combines initial body weight and RTU measurements, backfat thickness and marbling score, with economic data to project the number of days-on-feed that maximize profitability. The potential profitability of the KSU sorting system was shown on two feedlots in comparison with control pens, one sorted by weight, the other one unsorted. The derived profitability of this method applied three to four months before slaughter was $27.67 per head in the first feedlot and $15.22 per head in the second one.

Koontz et al. (2000) investigated marginal costs and returns associated with sorting cattle prior to marketing. The authors used a decision support system developed by Brethour (1989). The results show the potential benefit of the use of ultrasound in changing the composition of pens of heterogeneous cattle into more homogenous pens, 80 days before slaughter. The computed returns to sorting with ultrasound vary from $11 to $25 per head.

Lusk et al. (2003) investigated the comparative economic value of decisions based on ultrasounds measurements, taken on average 125 days before slaughter, with decisions using more restrictive information (weight, days-on-feed and breed). Their results show an improvement of $4.16/head in average returns using ultrasound measurements.

METHODS

Notation

In Table 1, the notation employed throughout the paper is given.

Table 1. Notation

i	subscript denoting animal number i ε {1, 2, …, 180}
j	subscript denoting date j ε {1, 2, …, 220}
k	subscript indicating marketing date k ε {160, 161, …, 220}
f	subscript denoting actual marketing date f ε {176, 182, 190, 196}
Ω_i	information set available for animal i
M	grid pricing formula M ε {low, medium, high}
$DOF_{i,k}$	days-on-feed for animal i marketed at marketing date k
$DOF_{i,f}$	days-on-feed for animal i marketed at actual marketing date l
DOF_i*	optimal days-on-feed maximizing returns to RTU for animal i
$rev_{i,k}$	revenue for animal i marketed at date k given Ω_i and M
C_i	costs for finishing animal i as a function of DOF_i
BP	base price
YP_i	yield premiums/discounts for animal i
QP_i	quality premiums/discounts for animal i
FC	daily feed costs
YC	daily yardage costs
OC_i	opportunity costs for animal i
PC_i	purchase costs for animal i
$YG_{i,k}$	yield grade for animal i at marketing date k
$QG_{i,k}$	quality grade for animal i at marketing date k
π_{i,DOF_i}	returns to RTU for animal i
$BF_{i,j}$	backfat for animal i at date j
$HCW_{i,k}$	hot carcass weight for animal i at marketing date k
$REA_{i,j}$	ribeye area for animal i at date j
$MS_{i,j}$	marbling score for animal i at marketing date k
LWi,j	weight for animal i at date j
$BF_{i,f}$	actual carcass backfat for animal i
$HCW_{i,f}$	actual hot carcass weight for animal i
$REA_{i,f}$	actual ribeye area for animal i
$MS_{i,f}$	actual marbling score for animal i

Analytical model

Beef producers are assumed to maximize returns to RTU given available information. The optimization problem can be expressed as

(1) $$\max_{DOF_i} \sum_i \pi_i = \max_{DOF_i} \sum_i \left[rev_i(DOF_i|W_i,M) - C_i(DOF_i) \right].$$

To maximize returns to RTU, feedlot operators choose the optimal length of feeding period for each animal *i*, DOF_i*. The number of days an animal *i* is fed (DOF_i) affects its carcass attributes: BF_i, REA_i, HCW_i, MS_i and, consequently, yield and quality grades on which the individual revenue is based. Yield grades are computed as (USDA, 1997)

(2) $$YG_{i,k} = 2.5 + 2.5 \times BF_{i,k} + 0.2 \times KPH_i + 0.0038 \times HCW_{i,k} - 0.32 \times REA_{i,k}.$$

Quality grades are determined by marbling score, as reported in Table 2.

Table 2. Quality grades

Grades*	Marbling score (MS)
Prime	≥ 700
High Choice	500 ≤ MS < 700
Low Choice	400 ≤ MS < 500
Select	300 ≤ MS <400
Standard	200≤ MS <300

* Source: USDA, 1997.

Individual revenue (rev_i) depends on premiums/discounts attributed to yield and quality grades. The revenue for animal *i* marketed at date *k* is given by

(3) $$rev_{i,k} = (BP + YP_i + QP_i) \times HCW_{i,k},$$

where *BP* is the base price, YP_i and QP_i are premiums/discounts associated, respectively, with yield and quality grades for the animal *i*.

The number of days animal *i* is fed (DOF_i) also affects costs. Beef producers bear feeding costs (*FC*), yardage costs (*YC*) and opportunity costs (*OC*) that are daily expenditures. The total costs for each cattle *i* is given by

(4) $C_i = (FC + YC + OC_i) \times DOF_i + PC_i$

where PC_i is the purchase cost of the animal *i*. Opportunity costs are computed as interest costs on the total investment for the animal *i*.

Feedlot managers are assumed to pursue the sole goal of maximizing economic profits. They seek to make the difference between total revenues and total economic costs as large as possible. Under this assumption, feedlot managers will make decisions in a "marginal" way (Nicholson, 2002). The decision variable, days-on-feed, will be adjusted until it is impossible to increase profits further. As long as the additional profit from one more day-on-feed is positive, an additional day-on-feed will be used. When the additional profit becomes zero, it is not profitable to extend the length of feeding period. The necessary condition to achieve profit maximization, choosing DOF_i*, is given by setting the first derivative of profit with respect to DOF_i equal to zero. Marginal revenue, in the first line of (5) can be thought of having two terms. The first term, comprised of the terms in the first parenthetical expression times HCW, is how price changes with an additional day-on-feed times HCW. An increase in DOF can increase yield grade, causing an increase in quality premium (or a decrease in quality discount). The second term in marginal revenue (last part of line of (5)) relates the increase HCW times price. Marginal cost is simply the change in total cost associated with an additional day-on-feed (i.e., yardage, feed and interest costs).

(5)
$$\frac{\Delta \pi_i}{\Delta DOF_i} = \left(\frac{\Delta BP}{\Delta DOF_i} + \frac{\Delta YP_i}{\Delta YG_i} \times \frac{\Delta YG_i}{\Delta DOF_i} + \frac{\Delta QP_i}{\Delta MS_i} \times \frac{\Delta MS_i}{\Delta DOF_i} \right) \times HCW_i + \left(BP + YP_i + QP_i \right) \times \frac{\Delta HCW_i}{\Delta DOF_i}$$
$$- \frac{\Delta C_i}{\Delta DOF_i} = 0$$

Based on the optimization principle to maximize profitability, feedlot managers should choose DOF_i* for which marginal revenue (MR_i) equal marginal cost (MC_i) (first-order condition for a maximum). That is:

(6) $MR_i = MC_i$.

Empirical model

The empirical model is divided in two steps. First, carcass characteristics – backfat thickness (BF), ribeye area (REA), marbling score (MS) and weight (LW) – are estimated as functions of prior measurements and days-on-feed. The regression models are used to project carcass characteristics to various days-on-feed. Second, the days-on-feed that maximize returns to RTU are determined under alternative price grids and marketing scenarios. Three price grids, low, medium, and high prices, are used. Marketing scenarios, one with individually optimized days-on-feed and another with "potloads" of cattle marketed, are considered. Both steps are discussed in detail below.

Econometric estimations and simulation

As revenue is a function of hot carcass weight, yield and quality grades, which in turn are functions of carcass characteristics, it is necessary to predict carcass characteristics using available information. The information considered here are the live animal measurements, including ultrasound and weights. For HCW, REA and BF, systems of equations are estimated using two-stage least squares regression. For MS, data from Bruns et al. (2004) are used to estimate a relationship between DOF and MS. KPH is assumed to be constant as little variability is observed in KPH scores for the research cattle.

Using the availability of live measurements and predictions for backfat, ribeye area and weight, made at two dates in the feeding period, one day-on-feed (DOF 1) and 160 days-on-feed (DOF 160), the regression model below is estimated.

$$(7)\begin{cases} BF_{i,k} = a_1 BF_{i,1} + a_2 BF_{i,160} + a_3 HCW_{i,k} + a_4 \log(DOF_{i,k}) + a_5 REA_{i,1} + a_6 REA_{i,k} + a_7 LW_{i,1} \\ REA_{i,k} = b_1 BF_{i,1} + b_2 BF_{i,k} + b_3 HCW_{i,k} + b_4 \log(DOF_{i,k}) + b_5 REA_{i,1} + b_6 REA_{i,160} \\ + b_7 REA_{i,160}^2 + b_8 LW_{i,1} \\ HCW_{i,k} = c_1 \left(LW_{i,160} - LW_{i,1}\right)/160 \times DOF_{i,k} + c_2 \left(LW_{i,160} - LW_{i,1}\right)/160 \times DOF_{i,k}^2 + c_3 BF_{i,1} \\ + c_4 BF_{i,k} + c_5 REA_{i,1} + c_6 REA_{i,k} + c_7 LW_{i,1} \end{cases}$$

To test for endogeneity of the system of equations given in (7), Hausman specification tests were performed. They indicate that endogeneity is present, so a two-stage least squares estimation is used (Pindyck and Rubinfeld, 1997). Instrument variables used are $BF_{i,1}$, $BF_{i,1}^2$, $BF_{i,160}$, $BF_{i,160}^2$, DOF_i DOF_i^2, $REA_{i,1}$, $REA_{i,1}^2$, $REA_{i,160}$, $REA_{i,160}^2$, $W_{i,1}$, $W_{i,1}^2$, $W_{i,160}$ and $W_{i,160}^2$.

Some variables are not included in the system because of multicollinearity. High simple coefficients of correlation between $BF_{i,1}^2$, $BF_{i,160}^2$, $LWi,_{160}$, $REA_{i,1}^2$ and other right-hand side variables might explain the presence of multicollinearity. $BF_{i,1}^2$ and $BF_{i,160}^2$, highly correlated with $BF_{i,1}$ and $BF_{i,160}$, respectively, are not used in the predictive equation of final backfat, $BF_{i,k}$ .The $LW_{i,160}$ variable is not included in the two first equations because of the presence $HCW_{i,k,}$ with which $LWi,_{160}$ is highly correlated. Also, $REA_{i,1}^2$, highly correlated with $REA_{i,160}$, is not used in the projection of final REA because of multicollinearity. In the third equation of this system, the factor $(LW_{i,160}-LW_{i,1})/160$ represents the average daily gain (ADG_i) between both live-weight measurements.

The system in (7) represents "full information" for the purpose of this study. The full information includes ultrasound measurements taken on DOF 1 and DOF 160. Two partial information scenarios are considered, one that considers only ultrasound measurements taken on DOF 1 and another that considers only ultrasound measurements taken on DOF 160. The same functional form as in system (7) is used for each of these partial information scenarios except that unused terms are dropped. For the DOF 1 measurements only scenario, $BF_{i,160}$, $BF_{i,160}^2$, $REA_{i,160}$, $REA_{i,160}^2$, $LW_{i,160}$ and $LW_{i,160}^2$ are dropped from the system and the instrument variables. Similarly, for the DOF 160 measurements only scenario, $BF_{i,1}$, $BF_{i,1}^2$, $REA_{i,1}$, $REA_{i,1}^2$, $LW_{i,1}$ and $LW_{i,1}^2$ are dropped.

Final marbling score projection is estimated using data from Bruns, Pritchard and Boggs (2004). Based on their results, projected marbling score at marketing date *k* for animal *i*, $MS_{i,k}$, is given by

(8) $$MS_{i,k} = MS_{i,f} + e^{5.8701} \times e^{0.0029 \times DOF_{i,k}} - e^{0.0029 \times DOF_{i,f}}$$

with $MS_{i,f}$ the measurement of marbling score at actual slaughter date *f*.

Using the estimated regression models for carcass characteristics, yield and quality grades are projected by varying DOF from 160 to 220 days. Return to RTU is computed for each animal for three price scenarios, low, medium and high base price grids.

Optimization

The second step of the empirical model employs the projected returns to RTU in two optimization models. First, using a grid search, the DOF_i that maximizes animal *i* return to RTU is found under each price scenario. This allows for determining the value of information collected using two ultrasound measurements versus one measurement. Second, total returns to RTU are maximized when cattle are constrained to be sold in groups of 45 head, or "potload." Due to trucking costs, cattle are usually marketed in potloads. (The study cattle were marketed by the cooperating producer in potload quantities.) A mathematical programming model, formulated as an integer program, is used to find four marketing dates, each with 45 head sold, that maximize total return to RTU.

Mathematically, the integer program is given as

(9) $$\underset{DOF_i}{Maximize} \sum_i a_{i,DOF_i} \times \pi_{i,DOF_i}$$

Such that

(10) $$\sum_{DOF_i} a_{i,DOF_i} = 1 \qquad \forall i$$

(11) $$\sum_{DOF} b_{DOF} = 4$$

(12) $$\sum_i a_{i,DOF_i} = 45 \times b_{DOF} \qquad \forall DOF$$

(13) $$\text{DOF}_i = \{160, 161, \ldots, 220\} \quad \forall i\,,$$

where a_{i,DOF_i} is a binary (0,1) variable and b is an integer variable ranging from 0 to 4. If a_{i,DOF_i} =1, animal *i* is to be marketed on DOF_i. If b_{DOF} = 1, 45 head are market on DOF where DOF ε {160, …, 220}. The constraint in (10) requires that each animal be sold only once, the constraint in (11) requires four marketing dates and (12) requires 45 head marketing groups. The last live measurements were taken on day 160, so the lower bound for days-on-feed is set to 160. Based on reasonable length of feeding period and computational considerations, an upper bound is set to 220 days-on-feed.

The optimization model is used nine times, three information scenarios × three price scenarios. Under the high price scenario, an additional simulation is used to project returns to RTU based on actual market dates for the study cattle. (The study cattle were marketed at the high price grid). These returns to RTU are compared to the high price scenario in the potload optimization model. These comparisons allow for the determination of the value of partial and full information relative to the information possessed by the cooperator, namely live weights and visual characteristics.

F-statistics and t-tests are used to compare the differences among the projected average returns to RTU resulting from the simulation and the average projected profit earned by the producer. The average projected profit is computed using projected carcass characteristics from the regression estimations for each information scenario and price level. Profit is improved if the average return to RTU is statistically greater than the projected profit. Statistic tests, F-statistics and t-tests, are also used to measure the accuracy of the predictive models. Average returns to RTU projected to the four actual marketing dates and the actual profit computed from the measured carcass data are compared. If these tests fail to reject that the projected returns and the actual profit are different, the accuracy of the models is confirmed. Further, correlations between the distributions of the projected returns to RTU and the distribution of the actual profit are used to assess the accuracy of the combined econometric and simulation models.

Data

Data collection

Individual live measurements, including live weight (LW) and ultrasound measurements of 12^{th} rib backfat thickness (BF) and ribeye area (REA) were obtained for

180 cross-bred steers in 2003-2004. Measurements were taken in Britton, SD, at two dates during the finishing period. The first measurements were taken when the cattle, approximately 8 months old, were placed on feed (November 25, 2003). The second measurements were taken three weeks before expected marketing (May 3, 2004). The actual marketing decisions were based on visual appraisals and live-weights. All finished cattle were slaughtered over a four-week period in May-June 2004 (May 20, May 26, June 3 and June 10). On the four marketing dates, 43, 38, 39 and 60 animals were slaughtered, at Tyson Fresh Meats™ in Dakota City, NE. On each of the marketing dates, cattle that were not included in the study were also marketed. Resulting in potloads quantities, approximately 45 head, sold on each date. The data set also contains carcass characteristics, including 12th rib BF, REA, MS and KPH (estimated by Dr. Paul Berg, Department of Animal and Range Sciences, North Dakota State University) and HCW, measured twenty-four hours after slaughter. Live measurements and final cattle characteristics are reported in Table 3.

The distributions of yield and quality grades, actually estimated on the slaughter floor, are shown in Figures 1 and 2. Most of the study cattle were Yield Grade 3 or lower (85%). Regarding quality, 74% of cattle were graded Low Choice or higher.

Pricing grids used in this study are reported in Table 4. Three price-grid structures, “low”, “medium” and “high”, were used in order to reflect uncertainty about prices. These price grids were taken from Bullinger (2005) and derived from USDA AMS (2004). The actual prices paid to the cooperating feedlot operator were similar to the “high” grid. Grids are assumed to remain the same over the finishing period and feedlot managers are assumed to know premiums and discounts they will receive for yield and quality grades emphasized in the grid.

Table 3. Animal characteristic statistics

	Mean*	Std Dev	Minimum	Maximum
Feedlot data				
Placement weight (pounds) LW_1	611	56	440	780
Actual days-on-feed *DOF*	189	8	176	197
Finished weight (pounds) LW_{160}	1198	84	941	1465
RTU measurements on DOF 1				
Ribeye area (square inches) REA_1	8	1	6	11
Back fat (tenth of an inch) BF_1	0.80	0.58	0.10	2.70
RTU measurements on DOF 160				
Ribeye area (square inches) REA_{160}	12	1	13	17
Back fat (tenth of an inch) BF_{160}	3.52	1.26	1.10	7.90
Carcass measurements				
Ribeye area (square inches) REA_f	13	1	10	17
Backfat (tenth of an inches) BF_f	4.98	1.87	1.20	14.00
Kidney Pelvic Heart fat (%) KPH_f	2.20	0.54	1.00	3.50
Hot Carcass Weight (pounds) HCW_f	789	53	625	966
Marbling score MS_f	452	94	260	860
Yield grade YG_f	3.12	0.81	0.97	5.37

*Number of observations = 180; REA_1, BF_1 and LW_1, respectively, ribeye area, backfat and live weight taken when animals were placed on feed (November 25, 2003); REA_{160}, BF_{160} and LW_{160}, respectively, ribeye area, backfat and live weight taken at the end of the feeding period (May 3, 2004); REA_f, BF_f, KPH_f, HCW_f, MS_f and YG_f are actual carcass measurements of ribeye area, backfat, kidney, pelvic and heart fat, hot carcass weight, marbling score and yield grade.

Costs over the feeding period

The length of feeding period (DOF) not only affects carcass traits but also costs associated with feed, yardage and interest. These costs were taken from Bullinger (2005). Daily feed costs were assumed to be equal to $1.36 per head, using actual invoices from the feedlot in Britton, SD. Daily yardage costs of $0.29 per animal represent fixed and marginal costs of maintaining feedlot property, facilities and machinery (suggested by Iowa State University, 2001). Interest costs were considered on the initial purchase of cattle (taken from USDA North Dakota Agricultural Statistics Service, 1999 and 2004) and also on feed and yardage costs accrued over the finishing period. An interest rate of 5.5% was used considering the actual interest rate realized over the feeding period.

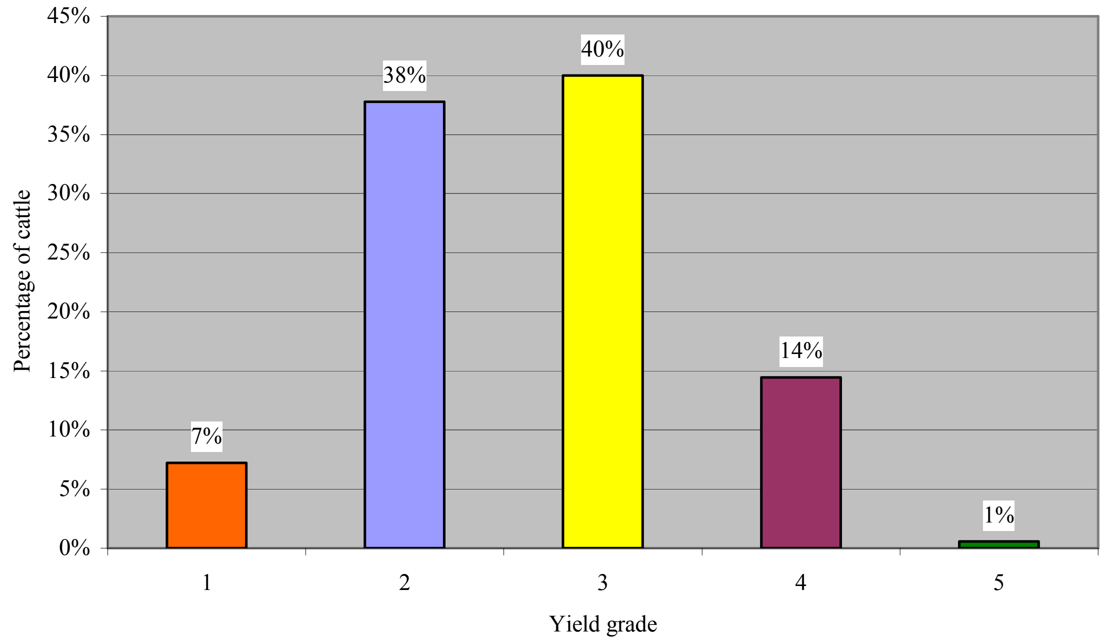

Figure 1. Distribution of actual yield grades.

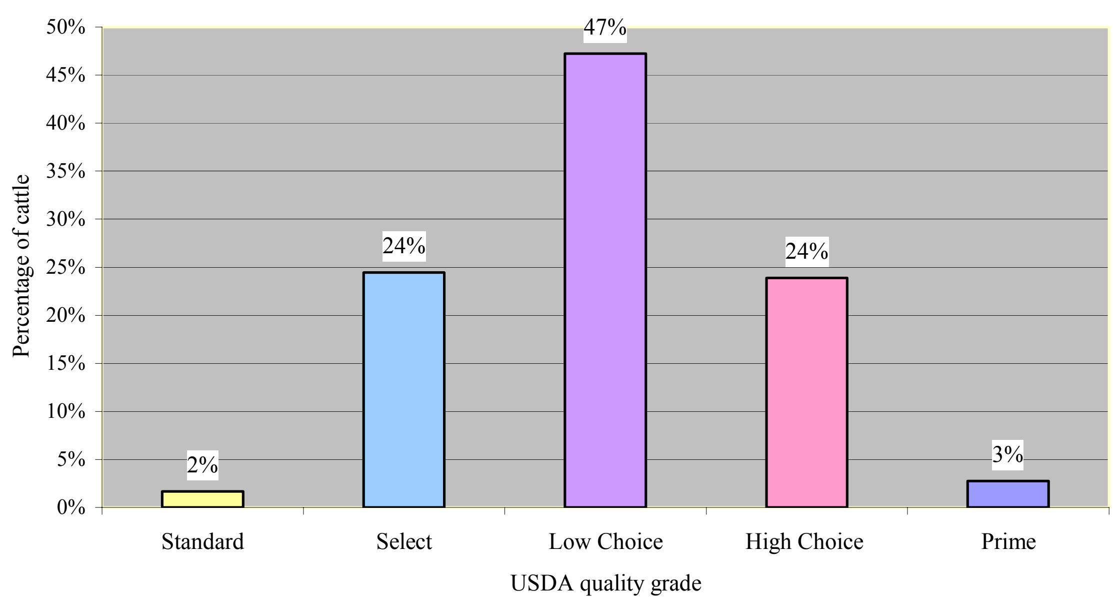

Figure 2. Distribution of actual quality grades.

Table 4. Pricing grid

Price-grid*	Price ($/cwt) low	medium	high
Base price	112.00	128.00	144.00
Quality grade adjustment			
Prime	12.20	18.30	24.52
High Choice	0.68	1.02	2.21
Low Choice	0.00	0.00	0.00
Select	-6.45	-8.07	-9.69
Standard	-13.89	-20.84	-30.00
Yield grade adjustment			
1.0-2.0	3.18	4.77	7.20
2.0-3.0	1.58	2.38	2.75
3.0-4.0	0.00	0.00	0.00
4.0-5.0	-14.04	-17.55	-20.00
>5.0	-18.32	-22.90	-25.00

* Source: Bullinger, 2005 (derived from USDA AMS, 1997).

RESULTS

Regression models

Results are presented for the regression models under full information, partial information with RTU measurements from DOF 1 and partial information with RTU measurements from DOF 160. Comparisons are made among the results.

Full information

Under the full information scenario (i.e., two RTU measurements of backfat and ribeye area), the two-stage least squares model leads to the results reported in Table 5. The final backfat thickness, BF_k, is significantly affected by all the variables including in the predictive equation. The initial backfat thickness, BF_1, the second backfat measurement, BF_{160}, the projected hot carcass weight, HCW_k, the logarithm of the length of feeding period, *log(DOF),* the ribeye area at feedlot entry, REA_1, the projected ribeye area at marketing, REA_k,, and the initial live weight, LW_1 significantly impact the final backfat thickness, considering a 10% level of significance.

Increasing the length of feeding period leads to thicker BF_k with a rate of growth decreasing over time. An increase in BF_1 increases BF_k by 0.53 inches. Similarly, an increase of one inch in BF_{160} leads to an increase in BF_k by 0.94 inches. An increase of 10 pounds in HCW increases BF_k by 0.005 inches. REA_1 is also positively related to BF_k. One square inch of REA_1 increases BF_k by 0.02 inches. Two variables, LW_1 and REA_k, are opposed to BF_k growing. Heavy entry weights, LW_1, are associated with lower BF_k. This is possibly due to faster growing cattle tending to be leaner. As expected, REA_k negatively affects BF_k, since ribeye area is associated with the leanness of the meat.

Significant variables to project final ribeye area, REA_k , are the final backfat thickness, BF_k, the logarithm of the length of feeding period, log(*DOF)*, the two live ultrasound measurements of REA, REA_1 and REA_{160} and also $(REA_{160})^2$, and the live weight taken at DOF 1, LW_1 . The insignificant variables are the hot carcass weight, HCW_k and the initial backfat measurement, BF_1, using a 10% level of confidence.

Table 5. Two-stage least squares estimated coefficients considering full information

	Full information Equation		
	BF_k (St Error)	REA_k (St Error)	HCW_k (St Error)
$ADG \times DOF$	-	-	0.7448***
	-	-	(0.0855)
$ADG \times DOF^2$	-	-	-0.0012***
	-	-	(0.0004)
BF_1	0.5334**	2.9485	-2.9919
	(0.2139)	(1.9572)	(51.6893)
BF_{160}	0.9356***	-	-
	(0.1014)	-	-
BF_k	-	-3.1360***	23.3570
	-	(0.6554)	(18.3704)
HCW_k	0.0005**	0.0036	-
	(0.0003)	(0.0022)	-
$log(DOF)$	0.0651**	2.9528***	-
	(0.0278)	(0.7517)	-
REA_1	0.0216*	0.3310***	3.8993
	(0.0127)	(0.0912)	(2.9775)
REA_{160}	-	-1.1356*	-
	-	(0.6253)	-
$(REA_{160})^2$	-	0.0658***	-
	-	(0.0248)	-
REA_k	-0.0318**	-	5.2098**
	(0.0124)	-	(2.3452)
LW_1	-0.0007***	-0.0052***	0.5343***
	(0.0002)	(0.0020)	(0.0357)
Instruments	BF_1, $(BF_1)^2$, BF_{160}, $(BF_{160})^2$, DOF, DOF^2, REA_{160}, $(REA_{160})^2$, LW_1, LW_1^2, , LW_{160}, $(LW_{160})^2$, REA_1, $(REA_1)^2$.		

* Significant at 10%. ** Significant at 5%. *** Significant at 1%.
Number of observations = 180; ADG = average daily gain; BF_j, REA_j and LW_j = backfat, ribeye area and live weight measured on jth date; BF_k and REA_k = carcass measurements of backfat and ribeye area; DOF = number of days-on-feed and HCW_k = hot carcass weight.

With a longer feeding period, REA increases at a decreasing rate. An increase of one inch of REA_1 increases REA_k by 0.33 square inches. The net effect of REA_{160} and $(REA_{160})^2$ increases REA_k. Final backfat thickness and final ribeye area are negatively related, as previously pointed out in the predictive equation of BF_k. As BF_k increases by one inch, REA_k decreases by 3.14 square inches. Heavy cattle at feedlot entry, LW_1, are more likely to have smaller ribeye area at slaughter, REA_k.

The interaction terms between average daily gain and days-on-feed, $ADG \times DOF$ and $ADG \times DOF^2$; final ribeye area, REA_k; and initial weight, LW_1, have a significant impact on hot-carcass weight, HCW_k. Initial and final backfat thickness, BF_1 and BF_k, and initial ribeye area, REA_1, are insignificant using a 10% confidence level.

As expected, HCW_k increases with the number of days-on-feed at a decreasing rate. Each square inch of REA_k is associated with an increase in HCW_k by 5 pounds. Leanness and hot carcass weight are positively related. Each 10 pounds of LW_1 increases HCW_k by 5 pounds.

Partial information: first ultrasound measurements

The next regression considers only the information collected from the first ultrasound measurements at DOF 1 and live weights as predictors of final characteristics. The system is derived from the full information system where the second RTU measurements are dropped. The results are shown in Table 6.

As fewer explanatory variables are employed, coefficients on the remaining variables differ in magnitude from the full information scenario. However, signs are unchanged, and significance is usually conserved. In comparison with the full information system, similar results are found for the prediction of BF_k, REA_k and HCW_k with few exceptions. In BF_k prediction, all right-hand side variables are significant. In the predictive equation of REA_k, the significant variables are BF_k, HCW_k, $log(DOF)$, REA_1 and LW_1; only BF_1 does not significantly affect REA_k. HCW_k *is* significantly affected by $ADG \times DOF$, $ADG \times DOF^2$, REA_1 and LW_1, whereas BF_1, BF_k and REA_k do not significantly impact HCW_k. The differences between this system and the full information system are twofold. The first concerns HCW_k in the REA_k equation. The second concerns REA_1 and REA_k in the HCW_k equation. HCW_k significantly affects REA_k with a positive impact. Heavy carcass weights are associated with larger REA at slaughter. Similarly, REA_1 significantly affects

HCW_k; one square inch of REA_1 leads to an increase of 11 pounds in HCW_k. REA_k is not significant in HCW prediction in this system.

Table 6. Two-stage least squares estimated coefficients considering partial information: first RTU measurements

	With one set of RTU measurements at DOF 1		
	Equation		
	BF_k (St Error)	REA_k (St Error)	HCW_k (St Error)
$ADG \times DOF$	-	-	0.7259***
	-	-	(0.1127)
$ADG \times DOF^2$	-	-	-0.0010**
	-	-	(0.0004)
BF_1	1.7619***	7.4461	-113.6934
	(0.2692)	(4.5300)	(98.2857)
BF_k	-	-5.9349***	54.8535
	-	(1.8152)	(40.0056)
HCW_k	0.0014***	0.0101***	-
	(0.0003)	(0.0031)	-
$log(DOF)$	0.1497***	1.4282***	-
	(0.0458)	(0.2720)	-
REA_1	0.0506**	0.6672***	10.7613**
	(0.0249)	(0.1007)	(4.3855)
REA_k	-0.0895***	-	-2.0172
	(0.0280)	-	(3.9867)
LW_1	-0.0013***	-0.0094***	0.5594***
	(0.0003)	(0.0029)	(0.0418)
Instruments	BF_1, $(BF_1)^2$, DOF, DOF^2, REA_1, $(REA_1)^2$, HCW, LW_1, LW_1^2, LW_{160}, LW_{160}^2.		

* Significant at 10%. ** Significant at 5%. *** Significant at 1%.
Number of observations = 180; ADG = average daily gain; BF_1, REA_1 and LW_1 = backfat, ribeye area and live weight measured on DOF 1; LW_{160} = live weight measured on DOF 160; DOF = number of days-on-feed and HCW_k = hot carcass weight.

Partial information: second ultrasound measurements

The final regression considers only the information collected from the second ultrasound at DOF 160 and live weights as predictors of carcass characteristics. The results are presented in Table 7.

Table 7. Two-stage least squares estimated coefficients considering partial information: second RTU measurements

	With one set of RTU measurements at DOF 160		
	Equation		
	BF_k (St Error)	REA_k (St Error)	HCW_k (St Error)
$ADG \times DOF$	-	-	0.7089***
	-	-	(0.0759)
$ADG \times DOF^2$	-	-	-0.0011***
	-	-	(0.0004)
BF_{160}	1.1546***	-	-
	(0.0754)	-	-
BF_k	-	-2.2904***	29.5730**
	-	(0.4694)	(11.6501)
HCW_k	0.0001	-0.0007	-
	(0.0002)	(0.0020)	-
$log(DOF)$	0.0600**	3.2867***	-
	(0.0294)	(0.7852)	-
REA_{160}	-	-1.1096*	-
	-	(0.6583)	-
$(REA_{160})^2$	-	0.0713***	-
	-	(0.0260)	-
REA_k	-0.0134	-	7.5856***
	(0.0097)	-	(1.5573)
LW_1	-0.0002	-0.0004	0.5529***
	(0.0002)	(0.0017)	(0.0309)
Instruments	BF_{160}, $(BF_{160})^2$, DOF, DOF^2, REA_{160}, $(REA_{160})^2$, HCW_k, W_1, W_1^2, W_{160}, W_{160}^2.		

* Significant at 10%. ** Significant at 5%. *** Significant at 1%.
Number of observations = 180; *ADG* = average daily gain; BF_{160} and REA_{160} = backfat and ribeye area at DOF 160; LW_j = live weight measured on j^{th} date; *DOF* = number of days-on-feed and HCW_k = hot carcass weight.

In the final backfat equation, BF_k, significant variables (using a 10% level) are BF_{160} and *log(DOF)*; insignificant variables are HCW_k, REA_k. and LW_1. In final ribeye area equation, REA_k, the following variables are significant: BF_k, *log(DOF)*, REA_{160} and $(REA_{160})^2$; insignificant variables are HCW_k and W_1. In the hot carcass weight equation, all included variables are significant. Again fewer explanatory variables are used from the full information model. All variables with significant coefficient have magnitudes that differ from the full information results. However, signs of the significant variables are unchanged from the full information model.

Optimization models

Two optimization models are used. The first optimization determines the days-on-feed for each animal that maximizes return to RTU. The second model maximizes total returns to RTU when cattle are marketed in potloads. Four marketing dates that maximize total return to RTU are determined, with 45 head per date.

Individual optimization returns to RTU

Using (1), the DOF_i that maximize total returns to RTU are determined. Using the results from the regression models, carcass characteristics are projected for $DOF_i \, \varepsilon \, \{160, 161, \ldots, 220\}$. The return to RTU for each animal associated with each DOF_i^* is determined. Using a grid search, the DOF_i^* that maximize (1) are found. Summary statistics for DOF_i^* under the three price scenarios are reported in Table 8. As price increases, cattle are fed longer under each of the information scenarios, as is suggested by (5). Since marginal revenue increases with higher prices, DOF_i^* also increase.

Table 8. Average days-on-feed for individual marketing

	Information scenarios*		
	Full	Partial RTU DOF 1	Partial RTU DOF 160
	(St Dev)	(St Dev)	(St Dev)
low grid price	186	185	193
	(22)	(22)	(20)
medium grid price	195	197	194
	(17)	(18)	(20)
high grid price	201	202	205
	(15)	(16)	(15)

* Full information includes two RTU measurements of backfat and ribeye area taken at DOF 1 and DOF 160; partial RTU DOF 160 information includes only one RTU measurement of backfat and ribeye area taken at DOF 160; partial RTU DOF 1 information includes only one RTU measurement of backfat and ribeye area taken at DOF 1.

Summary statistics for maximum returns to RTU under the three information scenarios and price scenarios are reported in Table 9. Average returns to RTU are highest under the full information scenario for any given price level. Average return to RTU is higher for partial information with RTU measurements from DOF 160 than for partial information with RTU measurements from DOF 1. These results demonstrate that 1) more information results in more accurate predictions and improved decision making and 2) projections based on RTU measurements taken closer to the end of the finishing period are likely to be more accurate.

Table 9. Average return to RTU ($ per head)

	Information scenarios*			
	Full	Partial RTU DOF 1	Partial RTU DOF 160	Projected profit
	(St Dev)	(St Dev)	(St Dev)	(St Dev)
Individual marketing				
low grid price	-19.72	-22.15	-21.28	
	(72.59)	(73.22)	(73.49)	
medium grid price	37.81	34.97	36.37	
	(76.63)	(76.77)	(77.50)	
high grid price	96.71	93.13	95.57	
	(81.20)	(81.44)	(82.03)	
Potload marketing				
low grid price	-23.02	-25.29	-24.34	
	(72.74)	(73.52)	(73.26)	
medium grid price	35.59	33.55	34.31	
	(77.06)	(77.57)	(77.82)	
high grid price	94.99	93.53	93.68	77.50
	(81.38)	(81.34)	(82.26)	(81.60)

*Full information includes two RTU measurements of backfat and ribeye area taken at DOF 1 and DOF 160; partial RTU DOF 160 includes only one RTU measurement of backfat and ribeye area taken at DOF 160; partial RTU DOF 1 includes only one RTU measurement of backfat and ribeye area taken at DOF 1.

The beef producer is assumed to maximize total profit. As consequence, if average returns to RTU are statistically different, then total returns to RTU are different. In Table 10, results for statistical testing of the differences in average returns to RTU are reported. F-tests are used to determine if average returns to RTU differ among the three information scenarios for a given price level. These tests indicate that there are no statistically significant differences among average returns to RTU of the three information scenarios for each price level.

Table 10. F-test comparisons of average returns to RTU under three information scenarios

Marketing Methods	Df*	F-statistic	Probability
Individual marketing			
high grid price	(2, 537)	0.090	0.914
medium grid price	(2, 537)	0.031	0.969
low grid price	(2, 537)	0.051	0.951
Potload marketing			
high grid price**	(3, 716)	1.853	0.136
medium grid price	(2, 537)	0.032	0.969
low grid price	(2, 537)	0.044	0.957

* Degrees of freedom.
** High grid price F-test compares per head returns to RTU among the three sets of information–two RTU measurements taken at DOF 1 and DOF 160, one RTU measurement taken at DOF 1, one RTU measurement taken at DOF 160–and the projected profit at actual marketing dates.

Potload marketing

Using the mathematical programming model given in (9)-(13), total return to RTU are maximized when the producer is constrained to market in potloads of 45 head. Four marketing dates that maximize total return to RTU, given 45 head sold per each date, are chosen, under each information and price scenario. The resulting marketing dates are reported in Table 11. Marketing dates are delayed as prices increase. Table 11 also reports the producer's four actual marketing dates for the high price scenario. The average returns to RTU for each information and price scenario are reported in Table 9.

Table 11. Optimal days-on-feed under marketing constraints

		Information scenarios*			
Price grid	Marketing Date	DOF 1 and 160 RTU	DOF 160 RTU only	DOF 1 RTU only	Actual marketing
low	1	160	168	160	-
	2	174	182	174	-
	3	188	201	185	-
	4	220	220	220	-
medium	1	174	169	174	-
	2	185	204	188	-
	3	201	207	207	-
	4	220	220	220	-
high	1	180	182	174	176
	2	196	201	178	182
	3	208	215	196	190
	4	220	220	220	196

*Full information includes two RTU measurements of backfat and ribeye area taken at DOF 1 and DOF 160; partial RTU DOF 1 includes only one RTU measurement of backfat and ribeye area taken at DOF 1; partial RTU DOF 160 includes only one RTU measurement of backfat and ribeye area taken at DOF 160.

F-statistics are used to evaluate the differences among the information and price scenarios and the actual marketing (Table 10). These tests indicate that the differences in average returns to RTU are not statistically significant different from each other and the average projected producer profit for each price level. However, t-tests, reported in Table 12, show statistically significant differences (10%) between the average returns to RTU and the projected average profit, indicating that the hypothesis of this study may be supported. If the cost of ultrasounding finishing cattle is less than the difference in returns to RTU and projected producer profits, feedlot profits can be improved by employing ultrasound measurements in models to predict carcass characteristics and profits.

The overall accuracy of the combined regression and simulation models is evaluated by comparing actual producer average profit and returns to RTU projected to the actual marketing dates. Actual producer profits are computed using the collected carcass data, the actual days-on-feed and the three price grids. Average returns to RTU are projected at the four actual marketing dates for each of the three information sets and the three price grids. The average returns to RTU and actual average profits are compared using F-tests and t-tests, reported in Tables 13 and 14. Using a 10% level of confidence, F-statistics indicate no statistically significant differences among the 3 average returns to RTU and average profit under the three price scenarios. However the t-tests show statistically significant differences when the average returns to RTU with two measurements and with the DOF 1 measurement are individually compared to the actual average profit. There are no statistically significant differences between the average returns derived from the use of RTU measurements made at DOF 160 and the actual average profits.

Table 12. T-test comparison between average returns to RTU and the projected average profit under high pricing grid

t-test* between projected profit** and	Df***	t-test	Probability
2 RTU return****	358	2.029	0.043
RTU DOF 1 return	358	1.861	0.064
RTU DOF 160 return	358	1.868	0.063

* Two-tailed t-test assuming unequal variance.
** Projected profit using regression estimations and projection of final characteristics at the actual marketing dates.
*** Degrees of freedom.
**** 2 RTU return considers two RTU measurements of backfat and ribeye area taken at DOF 1 and DOF 160; RTU DOF 1 considers only one RTU measurement of backfat and ribeye area taken at DOF 1; RTU DOF 160 includes only one RTU measurement of backfat and ribeye area taken at DOF 160.

In Table 15, correlations between the actual profit distribution and the distributions of projected return to RTU are reported. As is to be expected, the correlation between the actual profit and projected return to RTU with two measurements is higher than the other correlations. The correlation ranges from a high of 0.793 to a low of 0.673.

Table 13. F-test comparisons of projected average returns to RTU at actual marketing dates and the actual average profit under potload marketing

Pricing Grid	Df*	F-statistic**	Probability
low grid price	(7, 716)	30.710	0.000
medium grid price	(3, 716)	40.409	0.000
high grid price	(3, 716)	50.232	0.000

* Degrees of freedom.
** F-statistic compares per head returns to RTU using three sets of information–two RTU measurements taken at DOF 1 and DOF 160, one RTU measurement taken at DOF 1 and one RTU measurement taken at DOF 160–and the actual profit under three price levels: low, medium and high.

Table 124. T-test comparisons of average returns to RTU and the actual average profit

t-test* between actual profit** and	Df***	t-statistic	Probability
Low prices			
2 RTU return****	358	2.560	0.011
RTU DOF 1 return	358	7.770	0.000
RTU DOF 160 return	358	0.836	0.404
Medium prices			
2 RTU return	358	3.049	0.003
RTU DOF 1 return	358	8.983	0.000
RTU DOF 160 return	358	0.798	0.426
High prices			
2 RTU return	358	30489	0.001
RTU DOF 1 return	358	10.062	0.000
RTU DOF 160 return	358	0.759	0.448

* Two-tailed t-test assuming unequal variance.
** Actual average profit based on measured carcass data.
*** Degrees of freedom.
**** 2 RTU return considers two RTU measurements of backfat and ribeye area taken at DOF 1 and DOF 160; RTU DOF 1 considers only one RTU measurement of backfat and ribeye area taken at DOF 1; RTU DOF 160 includes only one RTU measurement of backfat and ribeye area taken at DOF 160.

Results regarding the combined accuracy of the models are mixed. While the t-tests indicate that average returns to RTU are statistically different from the projected average returns to RTU with two measurements, the F-tests failed to reject equal average profits and returns to RTU. Also, the correlations with actual profits are highest for the full information model. The projections using the RTU taken on DOF 160 are also highly correlated (0.761 to 0.776) with actual profits. Further, both F-tests and t-tests fail to reject equality of actual average profit and returns to RTU DOF 160. Based on statistical tests and correlations, the model using RTU DOF 1 is the least accurate.

Table 13. Correlations between the actual profit distribution and the distributions of projected returns to RTU

	Pricing grids		
Projected returns	Low	Medium	High
2 RTU	0.783	0.788	0.793
RTU DOF 1	0.673	0.682	0.690
RTU DOF 160	0.761	0.769	0.776

*Full information (2 RTU) includes two RTU measurements of backfat and ribeye area taken at DOF 1 and DOF 160; partial RTU DOF 1 includes only one RTU measurement of backfat and ribeye area taken at DOF 1; partial RTU DOF 160 includes only one RTU measurement of backfat and ribeye area taken at DOF 160.

CONCLUSIONS AND IMPLICATIONS

The objective of this study is to estimate the economic value of real-time ultrasound measurements in marketing cattle. Using data collected from 180 cross-bred steers, regression models are developed to estimate carcass characteristics. A simulation model then projects returns to RTU using the regression results. Data were collected using real-time ultrasound measurements. Three information sets are used. The first information set employs two ultrasound measurements, one taken at feedlot entry and another taken 160 days into the finishing period. The second and third information sets employ one ultrasound measurement, taken at 1 and 160 days into the finishing period, respectively.

Optimization models are developed to find maximum returns to RTU information for each information set under three price grids. Comparisons of average returns to RTU are made among the information sets and the actual profits earned by the producer.

When the feedlot operator is assumed to market cattle individually, the average return to RTU per head is increasing, as the price grid is higher, for each set of information. Using full information, partial information with RTU measurements from DOF 1 and partial information with RTU measurements from DOF 160, the per head average returns to RTU are respectively \$96.71, \$93.13 and \$95.57 under the high price grid, \$37.81, \$36.37 and \$34.97 under the medium price and -\$19.72, -\$22.15 and -\$21.28 under the low price grid. From F-test results, there are no significant differences (10%) among the average returns to RTU using the three sets of information, for each price grid. So, considering the costs of RTU measurements of backfat and ribeye area estimated to be \$9/head, the feedlot operator should only use one RTU measurement to aid marketing decisions.

Assuming marketing constraints – when the feedlot operator is constrained to market cattle in potloads of 45 head –average returns to RTU are lower than under individual marketing, as expected. Using full information, partial information with RTU measurements from DOF 1 and partial information with RTU measurements from DOF

160, the per head average returns to RTU are, respectively, $94.99, $93.53 and $93.68 under the high price grid, $35.59, $33.55 and $34.31 under the medium price grid and -$23.02, -$25.29 and -$34.34 under the low price grid. The cooperating producer's actual average profit is computed to be $77.50 under the high price grid. From F-tests, there are no statistically significant differences among the information scenarios when marketing in potloads. However, t-tests comparing per head average returns to RTU with the projected profit earned by the producer show statistically significant differences. Returns to full information, returns to partial information using RTU made at DOF 1 and returns to partial information using RTU average $17.49, $16.03 and $16.18. The use of ultrasound in marketing cattle can improve feedlot profits, if the cost of obtaining ultrasonic measurements is less than the average returns to RTU.

Considering the cost of ultrasound measurements ($8-$9 per head for backfat and ribeye area measurements), only one RTU measurement of backfat and ribeye area should be used. Including $9 for RTU measurement costs, the results indicate that the net average profit per head increase by $7.03 and $7.18 using one RTU measurement made at feedlot entry (DOF 1) and one RTU measurement made close to marketing (DOF 160), respectively. It does not appear to be profitable to utilize two RTU measurements in the feeding period considering the costs associated with this technology. Moreover, labor costs related to handle cattle for ultrasound measurements and weights were not included in the profit computation. The results also demonstrate that the closer to marketing measurements are taken, the more accurate the predictions will be. However, to avoid the risk of bruising and stress due to handling cattle close to marketing, feedlot operators might prefer RTU measurements made early in the finishing period. Also, feedlot operators might prefer RTU measurements made at feedlot entry (at the same time as live weights are recorded or as vaccinations are made) or at reimplanting to avoid added handling and costs associated with moving cattle.

A comparison between maximized average returns to RTU and actual marketing practices used by the cooperating producer demonstrates the economic value of RTU, assuming that the producer's goal is to maximize profit. However, results might differ depending on 1) the marketing practices and skills of the feedlot manager and 2) other behavior assumptions, such as risk aversion related to price volatility.

Further investigation is needed to improve the accuracy of the projected profit. Only the only use of RTU measurements made at DOF 160 into regression estimations of final characteristics seems to accurately predict the expected returns, based on t-statistics and correlations.

This study confirms results from previous research, the economic potential of RTU in cattle management (Basarab et al., 1999; Koontz et al., 2000; Lusk et al., 2003). The use of RTU technology in cattle marketing decisions appears to enhance feedlot profitability.

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