# ANALYSIS OF FACTORS AFFECTING COW AUCTION PRICE DIFFERENTIALS

**James Mintert, Joanne Blair, Ted Schroeder, and Frank Brazle**

**Abstract**

Data from Kansas cattle auctions were analyzed to estimate the impact a wide variety of physical characteristics had upon cow prices. Weight, lot size, health, pregnancy, grade, dressing percent, breed, time of sale, and market location were important factors affecting the differences in cow prices across lots on a given day. Results suggest that producers interested in maximizing the price they receive for their cows should market healthy cows in desirable lot sizes at higher dressing percentages.

*Key words*: cow prices, physical characteristics impact, auctions

## INTRODUCTION

The determination of cow prices involves the interaction of many factors. Price differentials among lots of cows reflect differences in the physical characteristics of the cows in various weight and grade categories. The magnitude of these price differentials reflect the expected differences in the product's value (Ladd and Martin).

Several studies have investigated the price premiums and discounts attributable to the characteristics of feeder cattle (Marsh; Buccola and Jessee; Buccola, 1980) and to the physical traits of individual lots of feeder cattle (Menzie, *et al.*; Sullivan and Linton; Kuehn; Faminow and Gum; Schroeder *et al.*). These studies indicate how feeder cattle physical characteristics impact feeder cattle prices, but they do not provide direct information regarding the impact of physical characteristics on cow prices.

Researchers have examined how factors such as seasonality, tax laws, and feeding costs impact the aggregate market for cull cows (Yager *et al.*; Innes and Carman). However, little research has been devoted to examining the values of physical traits expected to impact either cow or bull prices. Exceptions include the estimation of the marginal value of bulls that were expected to increase average weaning weights (Clary *et al.*) and Kerr's finding that the prices received for breeding bulls at Canadian auctions reflected their genetic characteristics. But these studies did not examine the effect of physical characteristics on cow prices. Given the importance of cull cow revenue to cow-calf producers, and the existence of previous research demonstrating that physical characteristics can significantly impact cattle prices, there is a need for research quantifying the impacts of physical characteristics on cow prices.

## PURPOSE OF STUDY

The selling of culled cows by cow-calf and dairy producers is an important component of U.S. cattle producers' revenue. According to U.S. Department of Agriculture estimates, an average of 14 percent of beef cow herds and 39 percent of dairy cow herds are culled and sold annually. Based on average cow inventory levels from 1984 through 1988, this implies that approximately 9 million cows were culled on an annual average basis during that time span. Given the 1984-1988 average cull cow price of $41.35 per cwt, annual average revenue generated from the sale of these cows likely exceeded $3.7 billion, more than 10 percent of all revenue generated by the sale of cattle and calves (*Agricultural Prices; Agricultural Statistics*). The revenue generated from the sale of cull cows is also significant when analyzed from the perspective of a commercial cow-calf producer. For example, using the above culling rate and price level, a 100-cow beef producer would have generated nearly $6000 in annual average revenue from the sale of cull cows during the 1984 through 1988 period.

This study examined the impact of a wide variety of physical characteristics on cow prices at several Kansas auctions. Physical characteristics such as weight, grade, dressing percent, health, and pregnancy, as well as breed, time of sale, and market location were variables included in a comprehensive model explaining short-term price variability. Additional knowledge of the price premiums and discounts associated with cow traits and characteristics is necessary to help facilitate improved production, management, and marketing decisions by cow-calf

James Mintert is Extension Agricultural Economist, Joanne Blair is a Research Assistant, Ted Schroeder is an Assistant Professor in the Department of Agricultural Economics at Kansas State University, and Frank Brazle is an Extension Specialist for livestock production in the Department of Animal Science and Industry, Kansas State University.

producers and cow buyers. Results of this research should help producers identify management practices that may directly impact the price received for their cows.

## PROCEDURE

The discovery of cow prices involves the interaction of many factors. Cow prices at a given market are expected to reflect regional and national supply-demand conditions, but are also sensitive to variations in local market supply-demand conditions. Since cow supply at a given auction is fixed in the short-run, price will be determined by the demand for the individual lot of cows at a particular market. The demand for any lot of cows will be influenced by the physical attributes of the cows in that lot. This suggests that price should be a function of the physical characteristics (C) of the particular lot of cows and fundamental market forces (M) reflecting cow supply and demand changes over the observed time period (Buccola). This relationship can be formulated as:

$$(1) \quad Price_{it} = \sum_{k} V_{ikt} C_{ikt} + \sum_{h} R_{ht} M_{ht}$$

where i refers to the lot of cows, k refers to a specific animal trait, h refers to market influence, and t represents the auction date. The value of each specific trait is represented by V, and R is the price effect of the fundamental market force. Equation (1) states that the price per hundredweight of each lot of cows on a given auction date will be the sum of the marginal implicit values of each lot's characteristics (Ladd and Martin) and the sum of the effects of market forces. Market influences in this study were estimated through the use of dummy variables that adjust for price changes across different auction locations, time of sale, and week of sale.

It was hypothesized that dressing percentage changes would explain a major portion of cow price variation, but the impact of these changes was expected to vary with both grade and weight. Consequently, interactions among grade and weight, grade and dressing percentage, and dressing percentage and weight were included in the model. Additionally, nonlinearities of selected attributes were incorporated into the model by including them as separate characteristics. Monetary values were assigned to the characteristics and market influences by estimating equation (1) with an ordinary least squares regression.

Estimation of equation (1) required the selection of a reference lot to obtain a regressor matrix of full rank. An arbitrarily chosen, open Hereford cow, in good health, with an average grade, selling in the first quarter of the auction, during the first fall week at market 1, was used as the reference lot. All price premiums and discounts were calculated relative to this standard lot. Each reported coefficient thus represents the price shift, holding all else constant, for a lot of cows deviating from the reference lot.

## DATA

Data on prices and physical traits of the cows were collected from seven weekly Kansas cattle auction markets. [1] The date, location, time of sale, lot size, price, average weight per head, breed, health, grade, dressing percentage, months pregnant, and age of bred cows were recorded for each lot sold. The fall data were collected from October 29, 1986 through December 13, 1986, and the spring data were collected from March 19, 1987 through April 25, 1987.

Data for lots of cows with average weights ranging from 500 to 1,730 pounds were used in this study. The data set included 4,711 lots of cows, consisting of 7,103 head. Sixty-six percent of the cow lots were sold in the fall and the remaining 34 percent were sold in the spring.

Demand for cows sold at the auctions included in this study is likely composed of demand for cull cows intended for slaughter as well as demand for cows suitable for use as herd replacements. Data detailing buyers' intended uses for the cows were not available, making it impossible to identify differences in the impact of various physical characteristics on cow prices depending on the source of demand for the cows. As a result, the price effects of some lot traits may have differed between packer buyers and those bidding on cows to retain for breeding purposes. For example, bred cows may garner a premium when purchased by cattle producers, but receive a discount from packer buyers. Similarly, certain breeds (e.g., longhorns) may attract breeder interest and thus receive premiums that would not be related to slaughter characteristics. However, it is likely that the vast majority of the cows included in this study were purchased for slaughter purposes, not as potential herd replacements.

## RESULTS AND DISCUSSION

Table 1 reports the averages and standard deviations of prices received, weights, grades, and dress-

[1] Data collectors were trained to evaluate cow characteristics in a systematic manner by the Department of Animal Sciences and Industry, Kansas State University.

Table 1. Averages and Standard Deviations for Selected Cow Characteristics

| Characteristics | Spring 1987 | | Fall 1986 | |
|---|---|---|---|---|
| | Average | Standard Deviation | Average | Standard Deviation |
| Price | $42.50/cwt | $5.88/cwt | $33.16/cwt | $5.23/cwt |
| Weight | 971.11 lbs. | 170.89 lbs | 968.05 lbs | 174.08 lbs |
| Dressing Percentage | 44.38% | 3.12% | 45.09% | 3.71% |
| Grade[a] | 2.31 | 0.61 | 2.57 | 0.70 |

[a]Grade was coded as very thin = 1 thin = 2 average = 3 and fat = 4.

ing percentages of cows sold during the data collection period. The averages are reported only to provide a reference to the levels of certain characteristics of cows sold. Estimated parameters and t-statistics from the regression results are presented in the Appendix Table A1. The model explained 67 percent of the variation in cow prices, and 37 of the 52 physical characteristics' coefficients were significantly different from zero at the .05 level. The models were also estimated with seasonal dummy variables included for the various physical characteristics, but no statistically discernable seasonal impacts were found.

Given the large number of regressors estimated, concerns were present regarding the potential upward biases in conditional variances of the estimated parameters as a result of multicollinearity. The regressors of the model were evaluated for the potential of degrading multicollinearity [2] using the regression-coefficient variance decomposition procedure of Belsley *et al.* (pp.98-114). This procedure suggested that two potentially degrading (nearly) collinear relationships were present. One was between the binary variable very thin and the interaction term between this binary variable and dressing percentage. This was likely a result of the fact that few cows were judged as very thin (4 percent) and most of these had similar dressing percentages. In spite of this multicollinearity, the coefficients on both of these variables were significantly different from zero at the .05 level suggesting that the collinearity was not sufficiently high to alter the conclusions. The other highly collinear relationship was among six regressors (the intercept, weight, weight squared, dressing percentage, weight-dressing percentage interaction, and weight-dressing percentage interaction squared). All six of these variables had coefficients significantly different from zero at the .05 level, suggesting that the collinearity was not severe. In light of the multicollinearity test results, it seems reasonable that multicollinearity was not severe enough to alter any of the conclusions drawn from the model.

Parameter estimates from this model represent the expected dollar per hundredweight discounts or premiums associated with the respective cow characteristics, relative to the base lot. The presence of quadratic and interaction variables, particularly among grade, weight, and dressing percentage, require that a degree of caution be used when interpreting the parameter estimates. The impact of all relevant variables should be evaluated prior to estimating the price impact of a particular characteristic. The premiums and discounts identified in the subsequent discussion are calculated relative to the aforementioned "base" cow. Positive price differences represent an expected premium over the base cow, whereas, negative price differences indicate an expected discount relative to the base cow. In order to enhance the interpretation of the estimates reported in the appendix (Table A1), the following sections examine more closely the price impacts of selected cow characteristics.

### Effect of Dressing Percentage and Weight

Figure 1 illustrates the premiums and discounts associated with varying dressing percentages on an average grade, 970 pound cow. A nearly linear relationship exists between the price received for a cow and her dressing percentage. Relative to the base dressing percentage of 45, discounts of $2.61 per cwt and $1.66 per cwt were received for cows with estimated dressing percentages of 40 and 42, respectively. Cows that had estimated dressing percentages of 48 and 50 brought premiums of $1.93 per cwt and $3.36 per cwt compared to the base cow.

[2] Collinearity was judged potentially degrading if the condition index was greater than 30 and the variance decomposition proportions among two or more estimated regression coefficients were greater than .50 (Belsley *et al.*). These results are available from the authors upon request.

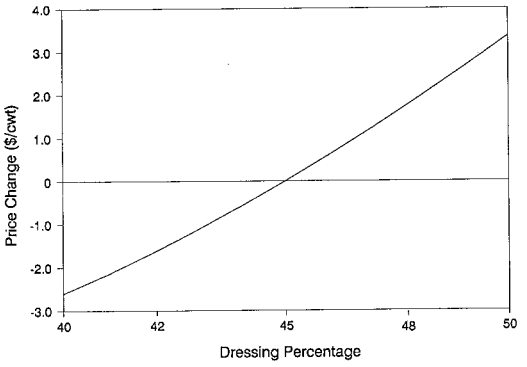


Figure 1. Effects of Dressing Percentage on Cow Price (average grade at 970 lbs)

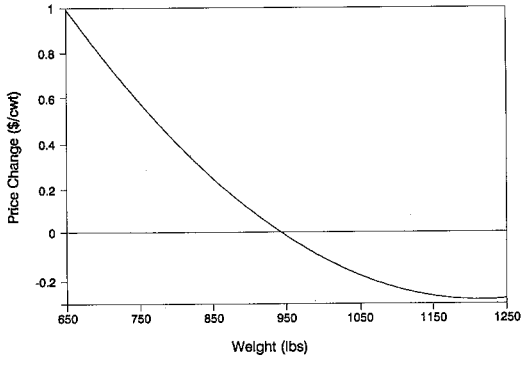


Figure 2. Effects of Weight on Cow Price (average grade, dressing percentage 45 )

The premiums and discounts associated with changes in the estimated dressing percentage are related to the expected change in the cow's carcass value.

The effect of weight on the price received for average grade cows is shown in Figure 2, for a fixed dressing percentage of 45. Cows weighing under 800 pounds received progressively higher premiums per hundredweight as their weight declined, relative to the base cow. As weight increased, the average price received per hundredweight (relative to 950 pound cows) decreased at a declining rate. Thus, weight had a nonlinear impact upon cow price.

Cattle producers seeking to improve returns when marketing cull cows should consider feeing light-weight cull cows with relatively low dressing percentages to increase both weight and dressing percentage. The dressing percentage of cows with estimated dressing percentages in the low 40s can often be increased by 4 percent or more without having a negative effect on the cow's grade. Additionally, healthy light-weight cows often respond well to high grain concentrate rations yielding very efficient weight gains. For example, if light-weight cows are fed 35 days on a high grain concentrate ration, an average weight gain of approximately 134

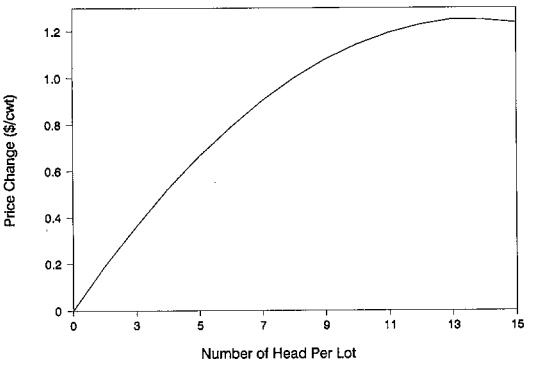


Figure 3. Effects of Lot Size on Cow Price

pounds can be achieved (Riley). A producer seeking to increase net returns following this feeding program might expect to increase the weight of a cow from 883 pounds (67 pounds below the 950 pound base cow in Figure 2) to 1017 pounds and, simultaneously, increase the dressing percentage from 43 to 47. Although increasing weight alone has a negative impact on cow price, the net effect is to increase the expected cow price by $2.17 per cwt as a result of the increase in the cow's dressing percentage and the interaction between weight and dressing percentage. Using the spring 1987 average cow price of $42.50 per cwt as a starting point, gross revenue received from selling the heavier cow with the higher dressing percentage, instead of the lighter cow, could be expected to increase by nearly $80. Prior to pursuing this strategy, cattle producers should evaluate other factors that will affect the profitability of this cull cow marketing strategy such as expected feed costs and expected changes in the cull cow price level during the course of the feeding period. However, these results do suggest that cattle producers should carefully evaluate this marketing strategy because it appears that feeding light-weight cull cows with relatively low dressing percentages could be a profitable practice.

### Effect of Lot Size

Approximately 82 percent of the lots consisted of a single head, 13.5 percent had 2 to 4 head, and the remaining 4.4 percent of the lots ranged from 8 to 20 head. Although single head lots were the most common size to be auctioned, 2 to 20 head lots brought premiums, on average, over single head lots as shown in Figure 3. Premiums were consistently paid for larger lots of cows, relative to single head cow lots (all else constant). Lot sizes of 11 to 15 head received an average premium of approximately $1.25 per cwt compared to comparable single head lots. However, lots of five head or more captured

over half of the $1.25 per cwt premium. These results suggest that the market especially discounts very small lots.

If feasible, cow-calf and dairy producers may want to consider culling and selling their cows in lot sizes of a least five head. In particular, larger producers who often cull cows over a period of several weeks will find it profitable to group cull cows into larger lot sizes to capture these premiums. Smaller producers who are unable to market cows in larger lot sizes without culling potentially productive cows early, will generally find that the lot size premiums are not large enough to encourage early culling. For example, by selling cull cows in a lot size of five head instead of one head, a cow-calf producer could earn a per-head premium of approximately $8.70 (assuming the cow weighed approximately 1000 pounds). However, the additional revenue generated by marketing the cull cows in a larger lot size could easily be offset by a drop in productivity associated with the replacement of a productive cow by a heifer. As a result, producers will not find it profitable to cull productive cows simply to capture premiums attributable to increasing lot size.

### Effect of Health

As would be expected, unhealthy cows received severe discounts that were highly significant (Table 2). Cows classified as having bad eyes (4.5 percent of the lots) were discounted nearly $9.00 per cwt or approximately 25 percent of the average price received for healthy cows. Based on the evaluators' visual appraisal, cows exhibiting signs of "hardware disease" [3] were discounted $5.33 per cwt relative to healthy cows. Finally, the presence of knots reduced the price received for cows by nearly $3.70 per cwt as compared to healthy cows. The market is sending a clear signal that cows having health problems will be severely discounted. However, decisions to cull cows before they become severe health risks or to nurse unhealthy cows into good condition should be based on the tradeoffs between the expected costs and risks of these choices, relative to the expected discounts unhealthy cows receive.

Table 2. Effect of Health on Cow Price

| Health | Percent of Cows | Price Change ($/cwt) |
|---|---|---|
| Bad Eyes | 4.5 | -8.97** |
| Hardware Disease | 0.4 | -5.33** |
| Knots | 5.0 | -3.69** |

**Indicates significantly different from zero at the .05 level.

### Effect of Breed

The premiums attributed to the various breed classifications relative to Herefords are presented in Table 3. Over half of the cows evaluated were classified as Herefords, Angus, or mixed lots of Herefords and Angus. No statistically significant price differences were identified between the Angus, mixed Hereford and Angus, and Hereford lots. Hereford-Angus cross cows received statistically significant, but relatively small ($0.35 per cwt), premiums relative to Herefords whereas exotic and exotic cross cows received premiums of $1.27 per cwt to $2.05 per cwt. Brahman cows received premiums over Herefords. Those judged to be less than 1/4 Brahman earned a $1.16 per cwt premium while those cows having more than 1/4 Brahman characteristics brought a $1.77 per cwt premium. Overall, it seems likely that the premiums paid for exotic cross cows were based on expectations of higher retail meat yields from the exotic cows com-

Table 3. Effect of Breed on Cow Price

| Breed | Percent of Cows | Price Change ($/cwt) |
|---|---|---|
| Hereford | 27.8 | Base |
| Angus | 19.6 | 0.24 |
| Herefords and Angus mixed | 7.0 | 0.33 |
| Hereford-Angus cross | 18.5 | 0.35** |
| Other English cross | 3.4 | 0.81** |
| Simmental, Charolais, Gelbvieh and Maine-Anjou | 9.6 | 1.27** |
| Other Exotic cross | 1.7 | 2.05** |
| Brahman (less than 1/4) | 1.5 | 1.16** |
| Brahman (greater than 1/4) | 0.3 | 1.77* |
| Dairy | 5.4 | 0.77** |
| Longhorn cross | 0.9 | 2.30** |
| Mixed | 4.2 | 2.12** |

**Indicates significantly different from zero at the .05 level.
*Indicates significantly different from zero at the .10 level.

[3] Hardware disease is a condition caused by ingestion of a metal object that has penetrated the rumen wall which typically leads to a significant enlargement of the cow's brisket.

pared to Hereford-Angus cross cows (Dikeman). Finally, Longhorn cross cows also received premiums averaging $2.30 per cwt over Hereford cows. Because less than 1 percent of the cows in the analysis were identified as Longhorn crosses, this premium could be attributable to a relatively small number of buyers desiring Longhorn cows for purposes other than slaughter.

### Effect of Time and Location of Sale

Little difference was found in the price received for cows sold during the first, second, and third quarters of the auction which accounted for 97 percent of the cows sold. Conversely, the 3 percent of the cows sold in the fourth quarter (after 8 p.m.) received a statistically significant discount of $1.76 per cwt. This result suggests that the time of sale has little effect on the price received, unless the cow is sold so late in the day that many potential buyers have left the sale site. The reduction of price toward the end of the sale concurs with the findings of Buccola (1982), Sosnick, Kuehn and others.

Significant price differentials were detected across market locations. Although the impact of market location and the day of the week the sale was held could not be examined simultaneously because of their perfect collinearity (i.e., each sale was held one day per week), it appears that the price differentials observed across markets were related to the day of the week the sale was held and the volume of that particular market. Using sales held on Thursday as a base, prices at Wednesday sales averaged approximately $.067 per cwt higher whereas prices at Friday and Saturday sales were $1.44 and $.090 per cwt, respectively, below those of Thursdays. Sales held on Wednesdays and Thursdays also tended to be the highest volume sales included in the study with volume at the Friday and Saturday sales well below those of the other two days.

### Effects of Age and Pregnancy

Pregnant cows received a premium over open cows, but the premium declined as the age of the cow increased. The estimated parameter of 0.876 for months pregnant (Appendix) must be multiplied by the number of months that the cow was estimated to be pregnant, and the estimated age of the cow must be multiplied by the age coefficient (-0.196) to generate an estimate of the price differential for a pregnant cow vs. an open cow. For example, a cow that was estimated to be five months pregnant and five years old would have received a premium of approximately $3.40 per cwt over an open cow. The premium that pregnant cows earned over open cows indicates that at least some of the buyers bidding at the auctions were seeking cows suitable for herd placement rather than slaughter, since pregnant cows would normally be discounted if purchased for slaughter. Finally, the premium for pregnant cows vs. open cows is small enough that cattle producers will generally not find this to be a realistic marketing option for cows. In other words, most producers will find it much more profitable, if circumstances permit, to retain the ownership of pregnant cows until calves are born rather than market pregnant cows.

## CONCLUSIONS

The purpose of this study was to determine the effect of a wide variety of physical characteristics on the prices received for cows. Cow prices were found to vary significantly with changes in weight, lot size, health, dressing percentage, breed, grade, auction location, sale week, and the interaction of dressing percentage and weight.

Results from this study suggest that cow buyers want healthy cows and will severely discount those perceived as having health problems. Selling cows in desirable lot sizes can improve the price received. Cows sold in lots of five head or more received over half of the total potential premium for lot size. Dressing percentage explained a major portion of the variability in cow prices. Cow buyers are primarily interested in the potential meat yield from a cow carcass and bid accordingly. Producers interested in maximizing the price they receive for their cows should primarily concentrate their efforts on marketing healthy cows in desirable lot sizes at higher dressing percentages.

## APPENDIX

| Characteristic[a] | Price Change ($/cwt) | t-Statistic |
|---|---|---|
| Weight | 0.131** | 3.557 |
| Weight Squared | -0.00005** | -2.606 |
| Very Thin x Weight[b] | -0.003 | -1.139 |
| Thin x Weight | -0.002** | -2.219 |
| Fat x Weight | -0.003 | -1.522 |
| Dressing Percent x Weight | -0.003** | -3.871 |
| Dressing Percent x Weight Squared | 0.000001** | 2.884 |
| Very Thin | -16.070** | -2.826 |
| Thin | -1.333 | -0.538 |
| Fat | 6.340 | 1.260 |
| Very Thin x Dressing Percent | 0.445** | 3.608 |
| Thin x Dressing Percent | 0.080 | 1.526 |
| Fat x Dressing Percent | -0.086 | -0.826 |
| Dressing Percent | 1.228** | 2.343 |
| Dressing Percent Squared | 0.015** | 4.111 |
| Head | 0.214** | 2.812 |
| Head Squared | -0.008* | -1.792 |
| Bad Eyes | -8.971** | -30.836 |
| Hardware | -5.334** | -5.324 |
| Knots | -3.690** | -13.354 |
| Age | -0.196** | -2.627 |
| Months Pregnant | 0.876** | 7.117 |
| Angus | 0.239 | 1.375 |
| Herefords and Angus Mixed | 0.331 | 0.884 |
| Hereford-Angus Cross | 0.354** | 1.998 |
| Other English Cross | 0.810** | 2.482 |
| Simmental, Charolais, Gelbvieh | 1.274** | 6.007 |
| Other Exotic Cross | 2.047** | 5.026 |
| Brahman (less than 1/4) | 1.161** | 2.299 |
| Brahman (greater than 1/4) | 1.768* | 1.734 |
| Dairy | 0.767** | 2.399 |
| Longhorn Cross | 2.297** | 3.324 |
| Mixed | 2.123** | 4.773 |
| 2nd Quarter | -0.014 | -0.060 |
| 3rd Quarter | 0.019 | 0.074 |
| 4th Quarter | -1.764** | -3.880 |
| Fall Week 2 | -2.500** | -8.914 |
| Fall Week 3 | -2.555** | -9.099 |
| Fall Week 4 | -1.894** | -7.444 |
| Fall Week 5 | -2.433** | -9.177 |
| Fall Week 6 | -3.135** | -11.675 |
| Spring Week 1 | 9.298** | 29.325 |
| Spring Week 2 | 7.278** | 23.749 |
| Spring Week 3 | 7.090** | 25.234 |
| Spring Week 4 | 8.342** | 26.649 |
| Spring Week 5 | 5.725** | 5.725 |
| Market 2 | 0.445 | 0.963 |
| Market 3 | 1.372** | 4.077 |
| Market 4 | 1.764** | 5.308 |
| Market 5 | 2.626** | 7.633 |
| Market 6 | 1.210** | 3.195 |
| Market 7 | 0.641* | 1.870 |
| Intercept | -46.324** | -2.281 |
| Adjusted R Squared | 0.67 | |
| RMSE | 4.03 | |
| F-Statistic | 184.60** | |
| Observations | 4711 lots; 7103 head | |
| Dependent Variable Mean | $36.28/cwt. | |

**Significantly different from zero at the .05 level.
*Significantly different from zero at the .10 level.

[a]Dependent variable is price ($/cwt). Independent variables are Weight=average weight (lbs/head); Weight Squared=(lbs/head)$^2$; Very Thin (Thin) (Fat)=1 if lot was very thin (thin)(fat),=0 otherwise; Dressing Percent=average estimated dressing percentage of cows in lot (%); Head=number of head in the lot (head); Head Squared=(head)$^2$; Bad Eyes (Hardware) (Knots)=1 if cows in the lot had bad eyes (hardware disease) (knots),=0 otherwise; Age=age of cow in years if she was pregnant,=0 otherwise; Months Pregnant=estimated number of months pregnant if bred,= 0 otherwise; Angus (Herefords and Angus Mixed) (etc., ..., Mixed)=1 if cows in lot were Angus (Herefords and Angus mixed) (etc., ..., Mixed),=0 otherwise; 2nd (3rd) (4th) Quarter=1 if cows sold during 2nd (3rd) (4th) quarter of the auction =0 otherwise; Fall (Spring) Week 1, 2,..., 6=1 if cow was sold during that week,=0 otherwise; Market 2,3,...,7=1 if cow sold at that market location,=0 otherwise. Markets are listed in random order to maintain anonymity.

[b]'x' indicates an interaction term *i.e.* one factor multiplied by the other.

## REFERENCES


Belsley, David A., Edwin Kuh, and Roy E. Welsch. *Regression Diagnostics*. John Wiley and Sons: New York, 1980.

Buccola, Steven T. "An Approach to the Analysis of Feeder Cattle Price Differentials." *Am. J. Agr. Econ.* 62(1980):574-580.

Buccola, Steven T. "Price Trends at Livestock Auctions." *Am. J. Agr. Econ.* 64(1982):63-69.

Buccola, Steven T. and David L. Jessee. "A U.S. Regional Model of Feeder Steer-Heifer Price Differentials. *So. J. Agr. Econ.* 11(1979):61-65.

Clary, G.M., J.W. Jordan, and C.E. Thompson. "Economics of Purchasing Genetically Superior Beef Bulls." *So. J. Agr. Econ.* 16(1984):31-36.

Dikeman, Michael E. "Evaluation of Beef Breeds for Meat Production." Beef Cattle Short Course Proceedings, May 6-8, 1987, University of Florida Cooperative Extension Service, Gainesville,

Faminow, Merle D. and Russell L. Gum. "Feeder Cattle Price Differentials in Arizona Auction Markets." *West. J. Agr. Econ.* 11(1986):156-163.

Innes, Robert and Hoy Carman. "Tax Reform and Beef Cow Replacement Strategy." *West. J. Agr. Econ.* 13(1988):254-266.

Kerr, William A. "Selective Breeding, Heritable Characteristics and Genetic-Based Technological Change in the Canadian Beef Cattle Industry." *West. J. Agr. Econ.* 9(1984):14-28.

Kuehn, J.P. "An Analysis of the West Virginia Livestock Auction Pricing Mechanism." Resource Management Series Number 77, Agricultural and Forestry Experiment Station, West Virginia Univ., September, 1979.

Ladd, George W. and Marvin B. Martin. "Prices and Demands for Input Characteristics." *Am. J. Agr. Econ.* 58(1976): 21-30.

Marsh, John M. "Monthly Price Premiums and Discounts Between Steer Calves and Yearlings." *Am. J. Agr. Econ.* 67(1985):307-314.

Menzie, Elmer L., Russell L. Gum, and C. Curtis Cable, Jr. "Major Determinants of Feeder Cattle Prices at Arizona Livestock Auctions." Technical Bulletin 197, Agricultural Experiment Station, Univ. of Arizona, September, 1972.

Riley, Jack. "Feeding Cull Cows." Report of Progress 320, Agricultural Experiment Station, Kansas State University, March 1978.

Schroeder, Ted, James Mintert, Frank Brazle, and Orlen Grunewald. "Factors Affecting Feeder Cattle Price Differentials." *West. J. Agr. Econ.* 13(1988):71-81.

Sosnick, S.H. "Bidding Strategy at Ordinary Auctions." *J. Farm Econ.* 45(1963):163-182.

Sullivan, Gregory M. and Daniel A. Linton. "Economic Evaluation of an Alternative Marketing System for Feeder Cattle in Alabama." *So. J. Agr. Econ.* 13(1981):85-89.

U.S. Department of Agriculture. *Agricultural Prices*. Washington, D.C., 1988.

U.S. Department of Agriculture. *Agricultural Statistics*. Washington, D.C., 1988.

Yager, William A., R. Clyde Greer and Oscar R. Burt. "Optimal Policies for Marketing Cull Beef Cows." *Am. J. Agr. Econ.* 62(1980):456-467.