The Value of Carcass Characteristic EPDs in Bred Heifer Price

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Paper presented at the NCR-134 *Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management*
St. Louis, Missouri, April 18-19, 2005

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This study used hedonic modeling to assess the marginal implicit value of bred heifer characteristics and of carcass characteristic expected progeny differences of bred heifer calves. Using data for 692 pens of Show-Me Replacement Heifers Inc. heifers marketed over the 2001 through 2004 period, we find heavier heifers are priced higher than lighter heifers, artificially inseminated heifer pens were premium priced, Angus animals received a premium, pens that are expected to calve at optimal period of the year and within a 30-day window received premiums, calf performance EPD birth weight was positive, only marbling carcass characteristic EPD was positive and significant, buyers prefer larger lots to smaller lots, buyers pay the highest price for lots sold during the mid-point of the sale, and buyers pay a higher price for a pen bred to the same sire. It may be that certain post-weaning carcass characteristics are not of value to buyers because they either sell at weaning or due to the co-mingling of cattle certain expected production capabilities are of little value.

Keywords: hedonic modeling, carcass characteristics, EPDs, heifers

Introduction

Beef industry participants are continually assessing means by which to trace genetic value through the supply chain and pass this information back to the respective segments of the industry. Some have attempted to trace meat all the way back to the cow-calf producer (pull system), while others target improved sire and heifer genetics to improve slaughter cattle quality (push system). To date, sire selection has played an important role in developing high quality feeder cattle for slaughter. For example, this is apparent with the use of the Angus Association's various carcass trait (e.g., ribeye area, fat thickness) sire expected progengy differences (EPDs) for arriving at an expected EPD value. This information represents the expected added carcass value, relative to the average, for sires with specific EPD levels. However, little is known as to the value cow-calf producers place on carcass characteristic EPDs. If cow-calf producers select sire semen based on carcass quality EPDs, then they should realize value associated with their selection. Also, synchronized and timed artificial insemination provides opportunities for coordinating genetics across multiple animals. Understanding what heifer and calf genetics characteristics buyers demand, and pay a premium for, will provide insight into what characteristics to coordinate through timed and synchronized artificial insemination. The objective of this research is to assess implicit values of bred heifer and expected calf productivity and quality characteristics.

We evaluate pens of heifers marketed through sanctioned Show-Me-Select Replacement Heifers, Inc. sales. Several conditions must be met in order for a producer to enter heifers in the Show-Me-Select Replacement Heifers, Inc. Heifers that are candidates for the program must be owned a minimum of sixty days before exposed for breeding. There are also health and vaccination guidelines for heifers at weaning, prior to breeding and at pregnancy examination. Heifers must be dehorned with scurs removed and they must be treated for internal and external parasites within 30 days of sale. Complete information on service sires must be available including sire breed, pedigree, and birth weight EPDs. Heifers must weigh a minimum of 800 pounds, receive a minimum body condition score of five, and be free of specified blemishes.

Prebreeding examinations include weight, reproductive tract score and pelvic measurements and are required for all program heifers. A certified screening committee from the Missouri Department of Agriculture screens heifers prior to sale. It is recommended that a brucellosis test is administered and the animal is free from any implants. Heifers approved by a certified team of inspectors receive a “Show-Me-Select” ear tag.

A coordinated beef system is not a new concept in the beef industry. Schroeder et al. (1998) summarize challenges in coordinating the beef value chain. Most attempts to coordinate the system have been either a push system where beef producers supply home-grown beef or a pull system where quality, e.g., grid pricing, is rewarded. However, little effort has been expended to match a push- and pull-system for beef. A timed and synchronized artificial insemination program provides the potential to match a push-system (focused on productivity measures) to a pull-system (calf carcass quality). This research provides beef industry persons with information of heifer quality and of calf carcass quality values.

Previous Research

Previous research evaluating price-characteristic relationships for breeding stock has been either cow-calf pairs (e.g., Parcell, Schroeder, and Hiner; Pierce, Parcell, and Randall) or purebred beef bulls (e.g., Dhuyvetter et al.; Richards and Jeffrey; Schroeder, Espinosa, Goodwin; and Wallburger). In evaluating cow-calf pairs, Parcell, Schroeder, and Hiner found significant nonlinear characteristic-price relationships between calf weight, number of pairs in pen, and cow age. Additionally, significant linear characteristic-price relationships existed for cow health, cow breed, bred back cows, registered cows, calf health, and calf frame. In analyzing purebred bull price differentials, Dhuyvetter et al. regressed bull price on physical and genetic characteristics, performance characteristics, expected progeny differences (EPDs), and marketing factors. They found nonlinear characteristic-price relationships for bull age and pen size. They found significant characteristic-price relationships for breed, most physical characteristics, birth weight, weaning weight, some expected progeny differences, and several marketing factors, e.g., sale date, picture, and percent of bulls in sale having a portion of semen rights retained by the seller.

Melton et al. analyzed factors affecting cow-calf prices by regressing cow and expected calf characteristics on cow-calf prices. Their data were for the 1984 to 1991 period. They conclude buyers pay more for increased birth weight, weaning weight, percent retail, 12-hour milk, and that buyers pay less for increased levels of marbling, average cow weight, lactation rate, and mature weight.

Walburger analyzed factors affecting variables of range bulls by regressing animal characteristics and expected production characteristic on bull price. Using a tobit model, he found increases in both back fat thickness and ribeye area to have a positive and statistically significant impact on price. An increase in lean meat yield was not statistically significant, but it appears the size of the coefficient is economically significant. Richards and Jeffrey analyzed factors affecting dairy bulls, and they compared a hedonic model to an industry standard Lifetime Profit Index, which is used to rank bull semen. They concluded that an increase in milk proof and protein proof had a positive and statistically significant impact on bull price. They also found that the hedonic price model was a better predictor of dairy bull prices than the Lifetime Profit Index.

Turner et al. analyzed the impact of actual carcass characteristic and ultrasound EPDs on bull prices. They concluded that an increase in carcass, ribeye, and % retail characteristics EPDS increases price, and an increase in fat characteristic EPD decreases price.

Biing-Hwani and Mori evaluated the value of beef carcass characteristics using import data into Japan. Four quality characteristics were analyzed; ribeye area, rib thickness, cold left-side weight, and cover fat thickness. These four factors determine Japanese of Ministry of Agriculture, Forestry, and Fisheries yield grade score. Also, the characteristics breed, sex, origin, and carcass weight are used to explain variation in carcass price. They find that marbling is most significant in price variation, and they find heavier animals (much heavier) are discounted.

Conceptual Model

Cow-calf producers produce calves for use in the production of beef. Bred heifers are inputs in the production of calves; therefore, bred heifers are inputs in the production of beef. The contribution of bred heifers to beef production is dependent on the inherent characteristics of the heifers and the expected characteristics of the calf. Assuming cow-calf producers maximize profits, the price (p_i) paid for a replacement heifer used as an input in beef production can be specified according to Ladd and Martin:

(1) $$p_i = \sum_j T_j \left(\partial x_{j.} / \partial v_i\right),$$

where *i* refers to a bred heifer, *j* refers to a specific known heifer characteristic or expected calf characteristic of bred heifer *i*, T_j is the marginal implicit price paid for the *j*th heifer or expected calf characteristic used in beef production, $x_{j.}$ is the total quantity of the *i*th input used for the production of the *j*th characteristic, and v_i is the quantity of the *i*th input used for beef production. The final term, $\left(\partial x_{j.} / \partial v_i\right)$ is the marginal contribution of characteristic *j* in beef production from the *i*th input. For example, this value represents the marginal change in total pounds of beef used in beef production as a result of an additional pound of calf expected progeny difference (EPD) carcass weight.

Equation (1) specifies the price paid for heifer *i* equals the sum of the value of the *j* characteristics of the heifer and expected characteristics of the calf. Following Ladd and Martin, $\left(\partial x_{j.} / dv_i\right)$ is assumed constant and equals x_{ji}. That is, using the calf carcass weight EPD example, increasing the calf carcass weight EPD by one will increase the expected total pounds of beef production by one. Therefore, equation (1) can be re-specified as:

(2) $$p_i = \sum_j T_j x_{ji}.$$

The marginal implicit value (T_j) need not be constant. Ladd and Martin indicated that T_j could be specified using a nonlinear functional form where the marginal implicit price for an individual heifer is dependent on the level of the characteristic. Bailey, Peterson, and Brorsen; Faminow and Gum; Mintert et al.; Parcell, Schroeder, and Hiner; and Pierce, Parcell, and Randall specified hedonic models of different inputs into cattle production as a function of the level of the characteristic using a quadratic functional form. That is, the level of a given input will influence the value of any additional quantity of that input. Therefore, some of the characteristics in this study are modeled such that the marginal implicit price varies with the level of the characteristic. As an example, using a quadratic functional form for one variable, calf EPD carcass weight, yields:

(3) $$p = \beta_1 \cdot x_{EPD\ carcass\ weight} + \beta_2 \cdot x^2_{EPD\ carcass\ weight} = x_{EPD\ carcass\ weight}(\beta_1 + \beta_2 \cdot x_{EPD\ carcass\ weight})$$

where the β's are estimated parameters, and $(\beta_1 + \beta_2 \cdot x_{EPD\ carcass\ weight})$ is the marginal implicit price ($T_{EPD\ carcass\ weight}$) of calf carcass weight EPD and varies with the level of calf carcass weight EPD observed.

Empirical Model

The present study will build on previous cow-calf and bull hedonic studies by developing a model of bred heifer characteristic-price relationships. Values reported for our research will need to be summed across the number of expected sired animals to a specific bull to obtain comparable values between previous research analyzing bull price and our research analyzing bred heifer price. The present study uses transaction level data on heifer price, physical characteristics, growth performance characteristic EPDs, carcass characteristic EPDs, and marketing factors for 642 pens of bred heifers marketed through sanctioned Show-Me-Select Replacement Heifers®, Inc. sales from 2001 through 2004. We specify a model where the average dollars per head value of pen *i* for sale *k* is specified as:

(4) $Price_{ik}$ = *f* (Heifer Physical and Calving Characteristics$_{ik}$, Calf Expected Growth Performance Charactersitics$_{ik}$, Calf Expected Carcass Performance Characteristics$_{ik}$, and Market Factors$_{ik}$).

Heifer physical and calving characteristics evaluated are weight, artificial insemination, breed, expected calving month, and expected span of calving dates for heifers within the pen. Heifer weight is specified linear to capture the higher price because of more pounds of beef and easier calving potential. Some previous studies have suggested the weight variable be non-linear (e.g., Mintert et al., Schroeder et al. (1988), Faminow and Gum) to capture discounts associated with lighter weight animals, however, for the present study lighter animals are not expected to be discounted because of program qualifications. A set of binary variables for whether the pen of heifers was naturally bred, artificially inseminated or mixed lot of naturally and artificially inseminated is specified (naturally sired is the default). It is expected that animals that are artificially inseminated receive a premium to pens that were bred naturally due to improved chances of sire identification and sire performance testing. Mixed lots are expected to have a premium less than an artificially inseminated pen. Most animals marketed through the Show-Me-Select Replacement Heifers, Inc. sales are of Angus breed or of Angus-cross breed. Therefore, the breed variable is specified as a binary variable set equal to one if the pen contains Angus genetics. A premium is expected for Angus animals, which is consistent with the findings of Parcell, Schroeder, and Hiner. Expected calving month is specified as three binary time periods of January and February, March and April, and October and November. March and

April is the default with a premium expected for the January and February period due to segregated birthing of heifers from the rest of the herd and a premium is expected for the October and November period due to calves weaned in April during the typical seasonal calf price peak. Pens of heifers expected to have a tighter calving span are expected to receive a premium because of lower management requirements and increased calf herd uniformity. The calving span variable is a binary variable set equal to one if the calving span is greater than 30 days.

Expected progeny differences (EPDs) for birth weight, weaning weight, yearling weight and maternal milk were included in the model. Birth weight is specified in natural logarithmic functional form so that a lower expected birth weight may be discounted relative to higher expected birth weights. For this analysis, we will not be surprised to find no discounts for high birth weight, while other studies have found substantial discounts, e.g. Dhuyvetter et al. and Turner et al., because Show-Me Replacement Heifers, Inc. protocol culls out animals with poor calving ease production characteristics. An increase in weaning weight EPD is expected to increase the pen average value. An increase in yearling weight EPD is expected to increase the pen average value. Maternal milk EPD is a measure of expected milk production of the female progeny and influences her calves expected growth performance during weaning. Because a female calf represents a possible replacement for the herd it is expected that a higher maternal milk EPD score is preferred, however, there is a relatively low probability that the calf born will eventually be a replacement animal. The maternal milk EPD variable was specified in logs with the expectation that low maternal milk EPD scores are discounted.

Calf carcass quality expected progeny differences refer to carcass weight, marbling, and ribeye area. While carcass weight EPD and ribeye area EPD are specified linear, marbling is specified in natural logarithmic form to account for lower marbling scores discounted because of the loss of potential grid pricing value. Carcass weight is a measure of potential calf meat yield. We expect carcass yield to add value linearly to the per head price for the pen average. Ribeye area is expected to have a positive impact on heifer price.

Sale dummies are specified separately as 0 or 1 binary values. Sale locations for Missouri are west central, southeast, and south central. West central is set as the default. Sale year is specified as a series of binary variables for sales in 2001, 2002, 2003, and 2004. The year 2001 is the default, with premiums and discounts expected to follow cattle prices across years. Lot order is specified quadratic with the variable indicating the percentile rank of the pen order of the sale. The percentile specification accounts for different size sales. For sanctioned Show-Me Replacement Heifers, Inc. sales, sale order is determined by random drawing. After the first round of producer lots is marketed, the sequential rounds are held until all producers have sold all animals. Typically, lower quality animals are sold early and late in the sale. Thus, we expect animals in the middle of the sale to receive premiums. Previous studies by Bailey, Peterson, and Brorsen; Faminow and Gum; Parcell, Schroeder, and Hiner; Schroeder et al. (1988); Turner, McKissick, and Dykes; and Ward included pen size as a predictor of animal value. Pen size is specified quadratic in this model. Most of the pens were relatively small (average pen size about 3) with only a few pens toward the large end (7 maximum). Missouri producers average about 35 cows per farm. If they replace 20 percent per year they will need seven replacement heifers. It is expected that larger pen within the range offered will receive premiums relative to smaller pens which would require buying multiple lots. Lastly, a variable that accounts for the number of bulls a pen is sired too is specified. For pen sizes greater than one, a variable accounting for the number of sires the heifer's in the pen were bred to was defined. This variable is specified as the ratio of heifers to sires, with a positive sign expected.

The bred heifer hedonic model was estimated using *Shazam* 9.0. Residual non-normality is a concern with hedonic models, so a Jarque-Bera test of the null hypothesis of residual normality was performed. The null hypothesis of residual normality was rejected. Models were re-estimated using the multivariate-*t*-errors robust estimation with three degrees of freedom and assuming independent residuals (Judge et al., Zellner). A similar procedure was performed by Dhuyvetter et al. in analyzing purebred bull price differentials.

Data and Results

Summary statistics for selected variables used in the hedonic model estimation are reported in table 1. Prices used in this model represent the average heifer price per head for a pen of heifers. Therefore, some characteristics are aggregate pen averages. Data were collected from six sale locations in the state of Missouri during the 2001 through 2004 period. Sales were widely advertised and open to the public. A total of 642 pens of heifers, 929 heifers, were auctioned at the different sales. Two data specification changes were made. First, sale order was expressed as a percentile of the number of pens of animals in a sale. This is done to recognize the time difference between sales with more or less lots, e.g., selling thirty pens at a particular sale location versus one-hundred and twenty-five pens at a second sale location. Last, EPD values range from negative to positive, which causes model specification problems when a negative EPD value is transformed to obtain a non-liner marginal implicit price schedule. To overcome this issue all EPD values had a constant added to preserve the variance. When simulating a variables impact on heifer price the adjustment was subtracted back out.

Regression results from the estimation of equation 4 are reported in table 2. The multivariate-*t* hedonic model estimated explained 73% of the variation in heifer prices across pens. Positive parameter estimates indicate a premium relative to the base heifer price. Negative parameter estimates indicate a discount relative to the base heifer price. A majority of the coefficients were significant at the 0.05 level.

Heifer physical and calving characteristics

A one pound increase in heifer weight led to a \$0.58/head increase in bred heifer price. This value is consistent with the marginal value of cull animals, which heifers will potentially represent in the future. Artificial inseminated heifers garnered a \$18.69/head premium to naturally bred heifers. Buyers apparently believe AI provides an increase in calf value to the calf. Angus breed, or Angus-cross breed, heifers were priced at \$58.96/head above non-Angus heifers. As nearly all bulls were of Angus breed, some of this premium represents the calf eventually receiving a Certified Angus Beef premium. Furthermore, Angus heifers can have additional Angus calves, or Angus-crossed calves.

Heifers scheduled to calve during the January/February calving period received a \$23.69/head premium relative to heifers scheduled to calve in March/April. This premium is likely reflecting producers desire to calve heifers prior to the remainder of the herd. Heifers scheduled to calve in October/November relative to March/April averaged a \$25.97/head premium. This premium reflects the added value for selling calves during the typical seasonal feeder-calf high in March/April.

There are substantial management costs with a long calving season. Also, calf uniformity may suffer from a more spread out calving season. Pens of heifers, greater than one heifer, having a calving span beyond 30 days were discounted $24.30/head relative to pens of heifers with a calving span less than 30 days.

Calf production expected progeny differences

All calf EPD variables were statistically different from zero. Birth weight EPD and weaning weight EPD were of the expected sign. Because heifer protocol program focuses on superior productive animals a large discount is associated with a low birth weight EPD (figure 1). This result is the opposite of previous studies evaluating purebred bull characteristics. For those studies, most semen is directed at commercial cattle herds where small calves at birth imply greater calving ease. An extra pound of expected calving weight increased heifer price by $5.53/head. This value is substantially larger than the expected market value for the calf at weaning. We can not explain this result. An extra pound of yearling weight was found to cause a $2.42/head heifer price discount. Because most buyers sell calves at weaning (Parcell et al., 2003) the sign of this variable is not surprising. An increase in the natural logarithmic of maternal milk decreased the bred heifer price by $25.62/head. It was expected that an increase in maternal milk would increase the bred heifer price. While higher maternal milk is expected to be associated with higher weaning weights, it also can lead to higher feed costs and more breeding problems if sufficient feedstuffs are not provided. Thus, buyers may actually believe the costs associated with increased milk levels outweigh the benefits, hence the discount

Calf carcass quality EPD

An increase in the calf EPD carcass weight did not have an impact on price, which is consistent with our expectations due to most buyers selling calves at weaning (Parcell et al.). The natural logarithmic of calf EPD marbling was statistically significant and of the expected sign. Low marbling EPD values caused price discounts and high marbling EPD values caused heifer price premiums. As marbling is an indicator of grade, the $50/head premium for expected high marbled calf is approximately equal to the either prime-to-select spread or choice-to-select spread on most grids. An increase in calf EPD ribeye area increased per head heifer price. As ribeye area represents the most valuable portion of the carcass a higher calf ribeye area EPD will lead to a potentially higher value animal. The results here point to an interesting conflict in buyer decision making. On one hand they pay a premium for calf carcass quality characteristics and pre-weaning production characteristics, but on the other hand they either discount or do not pay for post-weaning production characteristics.

Market Factors

As expected, regional differences in heifer value exist and heifer value followed the overall cattle market (table 2). Lot order and lot order squared represent the premium and discounts associated with the pens percentile order for the sale locations. Sale percentile order realized maximum value at the time of 55% to 70% of sales is complete (figure 3). This is consistent with sellers marketing their best quality heifers at the middle portion of the sale. Also, premiums do not drop off much toward the end of the sale. Because only sellers with a large number of lots will have cattle at the end of the sale, these sellers may be receiving a ‘buy or miss out’ premium.

An increase of one animal per pen increased the pen average per head price by $26.54/head. For example, a pen of four animals will garner a little over a $100/head premium to a single heifer pen. The squared term was not significant, so the impact is linear on price. For pens greater than one heifer, when all heifers are bred to the same bull a $7.59/head premium is observed. This represents the value to owning a highly predictive and efficient bull.

Conclusions

This study used hedonic modeling to assess the marginal implicit value of bred heifer characteristics and of carcass characteristic expected progeny differences of bred heifer calves. Using data for 692 pens of Show-Me Replacement Heifers Inc. heifers marketed over the 2001 through 2004 period, we regressed average heifer weight of the pen, heifer breed, siring method for the pen, expected calving period for the pen, calving span for the pen, calf birth weight EPD, calf weaning weight EPD, calf yearling weight EPD, calf maternal milk EPD, calf carcass weight EPD, calf marbling EPD, calf Ribeye area EPD, sale location, sale year, lot order, size of lot, and number of sires lot bred to on average heifer price for the pen.

Heavier heifers are priced higher than lighter heifers due to the increase pounds of meat. Artificially inseminated heifer pens were premium priced relative to naturally bred heifers, which may indicate buyers expected an increase in calf performance. Angus animals received a nearly $58/head premium. Pens of bred heifers scheduled to calve prior to when most cows in the herd calve received premiums due diversification of management intensity. Pens that calve outside a 30-day window were discounted relative to pens expected to calve inside a 30-day window. Calf performance EPD birth weight was positive, which reflects the impact of the programs focus on developing highly productive female cows. Buyers pay for higher EPD weaning weight, but buyers do not value yearling weight EPD or maternal milk EPD.

In general, calf EPD carcass characteristics were not important factors, other than marbling. This result is not surprising, given that most buyers to not retain ownership, but buyers prefer animals with a higher marbling level. One likely reason that buyers focus on marbling EPD is that this is a genetic factor that does not depend on the composition of the herd or pen of calves. Whereas, the post weaning production EPD values and carcass size EPD value reflect factors that are less achievable due to co-mingling of animals in the backgrounding and feedout phases of beef production.

Buyers prefer larger lots to smaller lots, and buyers pay the highest price to lots sold during the mid-point of the sale. Also, buyers pay a higher price for a pen bred to the same sire.

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Table 1. Summary statistics and expected sign of variables employed in the estimation of the hedonic bred heifer price equation (4).

Characteristic	Average	Standard Deviation	Expected Sign
Average price of heifer in pen ($/head)	1079.80	212.46	n/a
Average weight (lbs.) of heifer in pen	1031.7	115.5	+
Percentage of pens artificially inseminated sired	36.2		?
Percentage of pens mixed AI and naturally sired	13.7		-
Percentage of pens naturally sired	50.0		*default*
Percentage of pens Angus or Angus-cross breed	86.0		+
Calving period (% of pens calving in specified period)			
January and February	37.8		+
March and April	21.3		*default*
October and November	40.8		+
Calving span between first and last expected birth for pen (days)	11.9	12.4	-
Calf production expected progeny differences (EPD)			
Birth weight EPD	0.62	1.14	?
Weaning weight EPD	38.12	7.53	+
Yearling weight EPD	71.07	15.75	+
Maternal milk EPD	22.52	12.69	? to +
Calf carcass quality expected progeny differences			
Carcass weight EPD	8.13	8.08	+
Marbling EPD	0.19	0.17	+
Ribeye area EPD	0.13	0.15	+
Sale location (% of pens sold at location)			
Southeast	57.9		+
West central	16.8		*default*
South central	24.7		-
Sale year (% of pens sold in year)			
2001	5.5		*default*
2002	37.5		+
2003	41.5		-
2004	15.5		+
Number of head per pen	3.13	1.61	+
Number of lots sold per sale (% of number of total lots at sale)	54.2	0.29	?
Ratio of pens larger than one heifer divided by the number of sires heifers bred to.	1.64	1.34	+

Table 2. Replacement heifer characteristic demand model price estimates (dependent variable is average price per pen and coefficients refer to dollars per head).

Characteristic	Coefficient	t-stat
Heifer Physical and Calving Characteristics		
Weight	0.579***	14.630
Sire method of pen (*default* = natural)		
Artificial insemination	18.691*	1.645
Mixed	-15.772	1.185
Breed, = 1 if Angus	58.964***	4.713
Calving period (*default* = March and April		
January and February	23.698*	1.900
October and November	25.969*	1.729
Calving span, = 1 if greater than 30 days	-24.297**	1.754
Calf Production Expected Progeny Differences		
Birth weight (natural log)	32.710**	2.150
Weaning weight	5.529***	7.701
Yearling weight	-2.419***	5.928
Maternal milk (natural log)	-25.624**	2.437
Calf Carcass Quality Expected Progeny Differences		
Carcass weight	0.525	0.925
Marbling (natural log)	32.352***	3.611
Ribeye area	53.186*	1.754

Note: One, two, and three asterisks indicate coefficient significantly different from zero at the 0.10, 0.05 and 0.01 levels, respectively.

Table 2 (cont). Replacement heifer characteristic demand model price estimates (dependent variable is average price per pen and coefficients refer to dollars per head).

Characteristic	Coefficient	t-stat
Market Factors		
Regional sale variable (default = *west central*)		
Southeast	10.904*	0.868
South central	82.670***	6.336
Sale year (default = 2001)		
2002	-206.180***	10.250
2003	5.726	0.309
2004	321.630***	16.720
Lot order	127.910**	2.371
Lot order squared	-93.671*	1.804
Head per pen	26.54***	4.784
Head per pen squared	-1.012	0.7532
Ratio of pens larger than one heifer divided by the number of sires heifers bred to.	7.585*	1.725
Constant	316.670**	1.725
R – squared	0.7324	
Number of pens	642	

Note: One, two, and three asterisks indicate coefficient significantly different from zero at the 0.10, 0.05 and 0.01 levels, respectively.

Figure 1. Effect of birth weight EPD on price per bred heifer

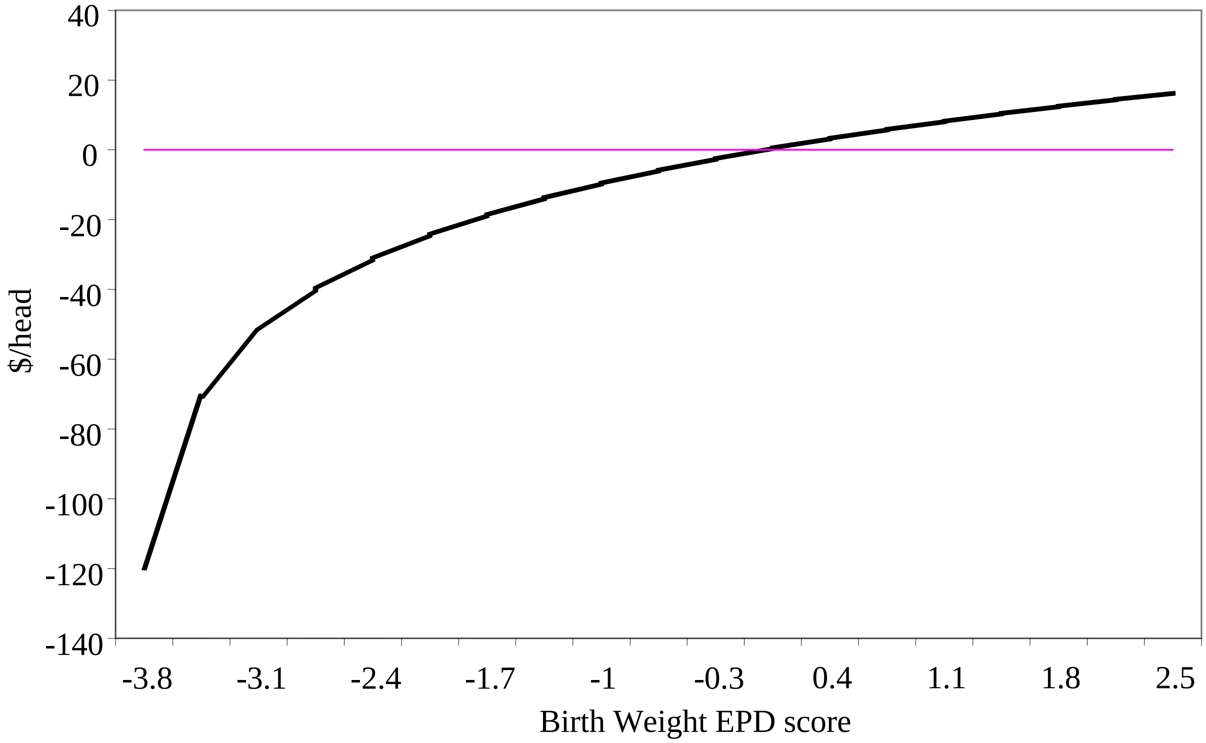

Figure 2. Effect of marbling EPD on price per bred heifer

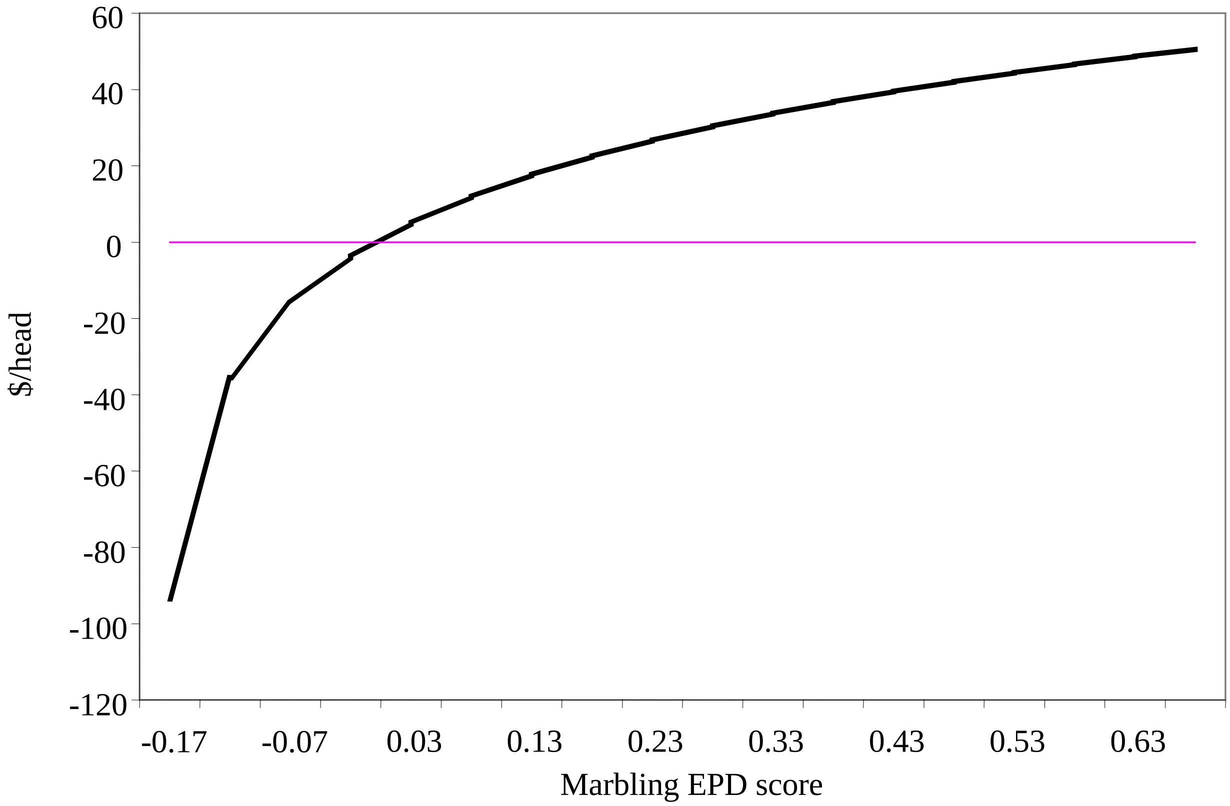

Figure 3. Effect of lot order on price per bred heifer