HEDONIC ANALYSIS OF PUREBRED BEEF BULL PRICES

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CHAPTER I

INTRODUCTION

"For each product consumed, the price paid for the product equals the sum of the marginal monetary value of the product's characteristics. We measure a product's characteristics in order to measure its quality. In doing this we replace the idea of 'product quality' by 'product qualities' and measure 'qualities' by measuring characteristics (Ladd and Suvannunt, 1976, 509)." As indicated above quality is measured by the product's package of characteristics. Lancaster (1971, 61) emphasizes characteristics as follows: Any good possesses an enormous number of physical properties: size, shape, color, smell, chemical composition, ability to perform any one of a variety of functions. "Productive inputs are useful because they contain useful characteristics. The total contribution of an input to production depends upon the amounts of the various characteristics it provides, and total production depends upon the total amounts of all characteristics provided by all inputs (Ladd and Martin 1976, 22)."

In order for producers of purebred beef breeding bulls to maximize the price paid for their product they must increase the perceived value of the purebred beef breeding bulls that they offer their customers. This can be done by improving the product's physical or genetic characteristics, or the total package of characteristics offered to the buyer from the producer. Each characteristic is valued differently. This may be due to the market fad at a particular time, or the input needs of the buyer at the time of purchase. Understanding the monetary value that each characteristic adds to the total package, and thus to the market price paid for the product, will increase the ability of management to select inputs, which will produce a product or package of characteristics that add the greatest value.

Problem Statement

Many previous studies beginning with Waugh in 1929 have indicated that many products exhibit heterogeneous characteristics. These studies have also shown that due to the heterogeneity of products, characteristics of these products also carry an intrinsic value. It is the combination of characteristics that determines the total value of the product.

Purebred beef breeding bull prices are determined by genetic, physical, and expected performance characteristics of the bull and their offspring as well as by marketing techniques not necessarily related to the quality of the bull (Dhuyvetter et al., 1996). Previous studies, using hedonic pricing models, have analyzed the value of a commodity input’s characteristics. Dhuyvetter et al. (1996) studied the value of individual physical and performance characteristics of purebred beef bulls. Parcell et al. (1995) introduced the need to understand the value and price determinants that establish the price of cow-calf pairs. Similar studies using a hedonic pricing analysis have examined the value of thoroughbred broodmare characteristics (Neibergs, 2001), and race-bred yearling quarter horse characteristics (Lansford et al., 1998). Other studies have examined information provided to the buyers at the time of purchase and how that information adds to the value of the input (Chvosta et al., 2001). Dhuyvetter et al. (1996) combined the evaluation of physical and performance characteristics as well as marketing techniques in determining the overall value of the total bull package. Chvosta et al. (2001) scrutinized presale measurement activities and the effect that providing the presale information on sale bulls has on reducing the transaction costs and estimated the value added to the bull package by presale information provided to the potential buyers (Chvosta et al., 2001). The studies by Chvosta et al. (2001) and Dhuyvetter et al. (1996) provide the foundation for this work.

The purpose of this study is to further analyze the information provided buyers of purebred beef breeding bulls in an auction setting and determine its affect on the price paid for bulls. This study will add a number of variables that the previous studies have not included. Variables added are ultrasound carcass measurements, carcass expected progeny differences (EPD's) and scrotal circumference. In addition, this study is unique because volume discounts are offered to buyers of bulls and the identities of the buyers of each bull are known. The effect that a volume discount has on the price paid for purebred beef breeding bulls is evaluated.

The sale of beef to the final consumer is a commodity market. When beef is harvested it is given quality yield grades. The price paid for the harvested beef is dependant upon the quality grade and yield grade. Due to the nature of beef production quality grades and yield grades are difficult to predict with the same accuracy as the production of grain. The difficulty of predicting these grades has lead to the development of carcass EPD's such as percent intramuscular fat (%IMF), rib eye area (REA), fat, and percent retail product (%RP). These measures are indicators of both the quality grade and yield grade that a particular beef animal will be assigned after slaughter. If a producer of beef were to be able to buy a superior bull that would increase the percent intramuscular fat, rib eye area, and percent retail product of his progeny, while decreasing the fat thickness, the producer would be paid a premium per pound of beef produced. This would lead to a higher sales and lower costs, thus producing a higher profit for the beef producer.

Due to the potential for higher prices that come from superior carcass genetics, beef producers have incentives to determine and measure the characteristics of their purebred beef breeding bulls, and their expected impact on offspring performance. These carcass traits and characteristics are considered to be moderate to highly heritable traits. The heritability and correlations for these carcass traits are as follows; carcass weight is 0.37, marbling is 0.46, ribeye area is 0.33, fat thickness is 0.33, and percent retail product is 0.29 (Crouch, 2000). These correlations suggest that using breeding stock that is superior in these carcass traits will lead to higher levels of carcass traits in their offspring, thus leading to higher prices for the beef producer.

In this study we will analyze the effects of both physical carcass measurements (obtained by using ultrasound imagining data) and carcass EPD's on the value of a breeding bull.

"Reproductive efficiency, obtained through cost-effective measures, is the most important factor affecting profitability of the cow-calf enterprise. The reproductive efficiency of bulls and females both contribute to expressed reproductive performance of the cow herd (Brinks, 1994, 2)." Scrotal circumference is one of the easiest and best measures of reproductive efficiency in young breeding bulls.

Many studies have shown that there is a relationship between scrotal circumference and semen quantity and quality. These studies show that there is a positive correlation to scrotal circumference in a yearling bulls, motility, percent normal sperm, semen volume, sperm concentration and total sperm output, and a negative correlation with percent abnormalities (Knights et al., 1984; Brinks et al., 1994).

It has also been shown that scrotal circumference is a tremendously accurate predictor of when a bull reaches puberty, exceeding age and weight as possible indicators of puberty. The average scrotal circumference of a bull that has reached puberty is 27.9 cm (Lunstra, 1982). Lunstra showed that there is a 0.98 correlation between the scrotal circumference of a bulls and the age at which heifers born from that bull reach puberty. The correlation between the scrotal circumference in yearling bulls and age at puberty in heifers was again reported by Brinks et al. (1994). These studies point toward a strong indication that age at puberty and scrotal circumference are closely related and may even be fundamentally the same trait (Lunstra, 1982). Numerous studies have indicated that scrotal circumference is a moderate to highly heritable trait and that selection would be effective in positively transforming the reproductive efficiency of a cow-calf enterprise (Brinks, 1994).

Due to the earlier maturation of these bulls and their offspring, there is an additional positive correlation in the weaning and yearling weights. It has been shown that bulls with above average scrotal circumference produce offspring with above average growth abilities (Brinks, 1994).

There are strong incentives for producers to increase the reproductive efficiency of their cow-calf enterprise. Ninety percent of the change in the genetics of a cow-calf enterprise is due to the sires (Wagner et al., 1985). Reproductive measures in bulls are extremely important and have the potential to greatly influence the profitability of a cow-calf enterprise. Selecting breeding bulls that have above average scrotal circumference should produce offspring, both male and female, that reach puberty quicker, have greater reproductive potential, and have above average growth.

In this study, the value that scrotal circumference is used to explain price of breeding bulls. Scrotal circumference is a measure easily obtained and may prove to be a relatively easy way to explain breeding bull values.

Dhuyvetter et al. (1996) evaluated a limited number of marketing techniques, in order to determine if value is attributed to marketing or auction techniques and not the individual bull being sold. The marketing techniques that have been largely studied include sale order, pictures and the retention of semen rights.

Sale order has been the largest studied marketing technique. Some studies have found that price declined as the sale progressed (Dhuyvetter et al., 1996; Minert et al., 1990; Schroeder et al., 1996), other studies found no significance to the auction order (Parcell et al., 1995) yet other studies found that prices increased as the auction progressed (Bailey et al., 1991). This variation in studies seems to be indicative of other key auction attributes that are not identical across sales. This may be due to the type of cattle being sold. A purebred cattle auction typically places the better quality cattle in the first part of the auction while leaving the moderate to lower quality in the middle to the end of the sale. In this instant one would find that, as the auction progressed the price paid would decline. Feeder cattle auctions do not necessarily place cattle in the auction order based on quality. Cattle order buyers often-frequent feeder cattle auctions and typically have a number of head of cattle needed to fill an order. If those orders are not filled by the latter part of the auction, demand may be high while supply may be low, and these order buyers must increase the price paid.

Picture or no picture is another marketing technique that has been frequently studied. This has been shown to be significant (Dhuyvetter et al. 1996).

Many times a seller will retain semen rights, show rights, or physical possession rights to a bull that is sold. Sellers typically retain some or all of these rights on bulls that they find to be of superior genetic value. The retention of these rights decreases the total package offered to the buyer. One would hypothesize that when decreasing the total package offered to the buyer the price paid for that package would also decrease. However, retained semen rights have been shown to positively affect the sale price of the bull being sold though this increase in price paid has been shown to decrease as the number of bulls with retained semen rights increases (Dhuyvetter et al., 1996). This may be due to the fact that the perceived value of the bull being sold increases as a result of the seller placing an interest in the future value of that individual bull. This perceived interest in the superior genetic value of an individual bull deteriorates as the seller increases the number of bulls in which interest is indicated.

This study will further address affect of marketing techniques on the value of the price paid for a purebred beef breeding bull. Additionally, this study will use data gathered from a traditional English style auction involving a one large breeder of purebred beef breeding bulls. This breeder raises purebred Angus as well as purebred Limousin breeding bulls. The data gathered spans a two and one-half year period of time from 2002 to 2004 and includes 1128 observations. The breeder has instigated a volume buyer program to reward the volume buyers as well as to initiate additional purchases. We have been given the names of each buyer and the bull or bulls that they purchased. Using this information, the effect of a price discount given to volume buyers has on the price paid for a bull is estimated.

Objectives

The general objective of this thesis is to determine the effect information provided to buyers of purebred beef breeding bulls in an auction has on the price paid for bulls.

The specific objectives of this thesis are to:

1. Determine the effects of both physical carcass measurements and expected progeny differences on the price paid for breeding bulls; and
2. Determine the effect that scrotal circumference has on purebred beef breeding bull prices; and
3. Determine the effect of a price discount given to volume buyers on the value of a breeding bull.

CHAPTER II

THEORY AND APPLICATION

As discussed in the Ladd and Martin study, on the role of input prices in the production process, differences in input characteristics affect the production process (Ladd and Martin, 1976). Neoclassical theory of the firm assumes homogeneity of inputs. This assumption, however, is not adequate in many markets for inputs. Considering purebred beef breeding bulls are a major input in the production of beef, the neoclassical theory of the firm's assumption of homogeneity of inputs would be considered inadequate. This heterogeneity of inputs leads to a difference in the value and the price paid for the input.

In evaluating the price difference associated with the heterogeneity of the input, we use a variation of the neoclassical theory of the firm presented by Ladd and Martin (1976), and two models that have been used to derive the value associated with each characteristic that constitute the total value of the purebred breeding bull.

Prices and Demand for Input Characteristics, 1976

Ladd and Martin derived a variation of the neoclassical theory of the firm that they term the Neoclassical Input Characteristic Model (ICM). This model differs from the neoclassical theory of the firm by taking into account the heterogeneity of inputs. Ladd and Martin introduce two themes. The first theme states that the "purchased input equals the sum of the money values of the input's characteristics to the purchaser (Ladd and Martin, 1976, 21)." Furthermore the "money value of each of the input's characteristics equals the input's marginal yield of the characteristic multiplied by the marginal money value of one unit of the characteristic (Ladd and Martin, 1976, 21)." Inputs into production are central to the production process, due to the characteristics that they pass on to the end product. In the production of beef products, the genetic inputs are the sire and dam. These inputs contribute a great portion of the characteristics of the end beef product. Furthermore purebred beef breeding bulls are considered inputs to the producers of beef.

The second theme introduced by Ladd and Martin (1976, 21) is "the demand for an input is affected by the input's characteristics." Basic economic theory suggests that as the quantity demanded for a good increases the price of said good increases. The price of an input is related to the input's characteristics. Given knowledge of the relationship between price and input characteristics, producers can determine which characteristics have the greatest impact on price and increase the level of that characteristic in their product.

Models Deriving The Value Associated With Purebred Beef Breeding Bull Characteristics.

Two models have previously been developed to estimate market values associated with specific bull's phenotypic and genotypic characteristics. These models also attribute market values to non-bull specific characteristics. These non-bull specific characteristics are usually attributed to marketing efforts.

Determinants of Purebred Beef Bull Price Differentials, 1996

Dhuyvetter's model assumes that the derived demand for purebred beef breeding bulls is a function of expected calf prices and productive capabilities. They further assume the expected calf price is constant at any given period in time and therefore it is determined that the demand for purebred beef breeding bulls is a function of the bull's productive characteristics. The model used by Dhuyvetter et al. is derived from the Ladd/Martin ICM and has been used in various other pricing models (Dhuyvetter et al,. 1996; Bailey, Peterson, and Brorsen., 1991; Jones et al., 1992; Parcell, Schroeder, and Hiner, 1995). The price of a purebred breeding bull can be specified as:

$$r_i = \sum_j T_j (\partial x_j / \partial v_i) \quad (1)$$

where i refers to the individual purebred breeding bull, j refers to the purebred beef breeding bulls characteristics, T_j is the marginal implicit price paid for the jth characteristic, x_j is the total quantity of characteristic j that enters beef production and v_i is the quality of the ith input used in beef production (Parcell, Schroeder, and Hiner, 1995). Equation (1) specifies the price paid for each purebred beef breeding bull equals the sum of the marginal yields of the bull's characteristics $\partial x_j / \partial v_i = x_{ji}$. Assuming that the marginal yields of purebred beef breeding bull characteristics in beef production are constant we can also assume that $\partial x_j / \partial v_i = x_{ji}$ is also constant. This implies that equation (1) can be written as

$$r_i = \sum_j T_j x_{ji} \quad (2)$$

Equation (2) can be estimated to determine the marginal implicit prices associated with purebred breeding bull characteristic data and associated prices paid for the bulls

(Parcells, Schroeder, Hiner. 1995). This is the model that Dhuyvetter et al. uses to estimate the marginal implicit prices associated with purebred beef breeding bulls.

Dhuyvetter et al. splits bull characteristics into two categories: physical and genetic characteristics (phenotype and genotype), and expected performance characteristics (EPD's). They then add in an additional marketing factor, which leads to the following function.

(3) $\text{Bull Price}_i = f(\text{Physical and Genetic Characteristics}_i, \text{Expected Performance Characteristics}_i, \text{Marketing Factors}_i)$.

Dhuyvetter et al. concluded that performance variables were important in explaining price variability in most breeds of cattle. Of particular interest to this study is that EPDs were found to be significant in explaining the price of Angus, Gelbvieh and Simmental breeds but less in other breeds such as Limousin (Dhuyvetter et al. 1996).

Transaction Costs and Cattle Marketing: The Information Content of Seller Provided Presale Data at Bull Auctions, (2001)

Chvosta, Rucker, and Watts (2001) study the impact of information provided to the buyers of purebred beef breeding bulls sold at auction on prices of bulls. Uncertainty exists when buying a purebred beef breeding bull. Uncertainty contributes to transaction costs. These transaction costs arise because buyers desire to undertake presale measurement activities to better predict the characteristics that are both desirable and those that are undesirable. Physical measurements of the purebred beef breeding bull, such as birth weight, adjusted yearling weights, scrotal circumference and rib eye area are now available. Chvosta et al. (2001) refer to these as simple performance measures (SPM). A more sophisticated set of performance measures has been developed in the past three decades. These performance measures, referred to as expected progeny differences (EPDs) make in-breed comparisons to help determine which animals exhibit superior traits compared to its breed peers. Chvosta et al. (2001) analyze the relative information content of EPDs and SPMs and their relative impact on the prices paid for bulls.

To analyze the impact EPDs and SPMs on the price paid for purebred beef breeding bulls Chvosta et al. (2001) obtained data from Angus bulls sold at auction. They obtained the sale catalogs that were provided to the prospective buyers when these bulls were sold. These catalogs ranged from the years of 1982 to 1996. To analyze this data Chvosta et al. (2001) estimate hedonic regressions in which the price paid for a particular bull is determined by the perceived attributes of the bull, expected future market conditions, and by the terms of the sale agreement (Chvosta et al. 2001). The authors use a hedonic model applied in numerous works by, Griliches (1971), Rosen (1974) and Palmquist (1989). The hedonic model determines the coefficients from a regression of a good's price on those goods attributes and provides measures of the market valuation of those attributes.

Chvosta et al. (2001) hypothesized that the function for the price paid for a bull is

(4) Bull Price= *f*(Beef Price, Feed Price, Age, Performance Measures)

where beef and feed prices are the expectations of future beef and feed prices; age is the age of the bull on Janurary 1 on the year of the auction; and the performance measures are in a vector of indicators of future performance (Chvosta et al. 2001).

Chvosta et al. (2001) defined the following function to estimate the economic values of SPMs and EPDs.

(5) $$p = a_1 x + a_2 z + a_3 u + \varepsilon$$

where *p* is the price paid for the bull, *x* is the information contained in SPMs, *z* is the additional information contained in EPDs, *u* is any other relevant observable information, and ε is any other unobservable information. Now let SPMs remain *x*, and EPDs be $g(x,z) = g_1 x + g_2 z$. The regression that they focus their discussion on is

(6) $$p = b_1 x + b_2 g(x,z) + b_3 u + \eta$$
$$= b_1 x + b_2 (g_1 x + g_2 z) + b_3 u + \eta$$

where η is the error of the regression model.

In order to control for genetic and technological advances the Chvosta et al. (2001) detrend the SPM and EPD performance measures using the annual herd average.

(7) $$\text{Detrended Performance Measure}_{it} = \frac{\text{Performance Measure}_{it}}{\text{Performance Measure Herd Average}_{t}} * 100$$

where $\text{Performance Measure}_{it}$ is a performance measure for bull *i* in time *t*, and $\text{Performance Measure Herd Average}_{t}$ is the herd average of the performance measure at time *t*.

Chvosta et al. (2001) determined in their study that SPMs have more economic value then do the EPDs. However, part of the Chvosta et al. (2001) study also examined a time period before EPD's were used and after EPD's were added. They found through price decomposition that the introduction of EPDs had added considerable value. "At a minimum, our results suggest that buyers find EPDs to be relatively more useful in making comparisons between herds than within herds (Chvosta et al. 2001, 300)."

CHAPTER III

DERIVATION AND ESTIMATION OF PRICING MODEL

This chapter will discuss the data used to estimate the pricing model. Additionally the conceptual model and the statistical methodologies that are used in estimating the pricing model are presented.

In this study we use Dhuyvetter et al.'s (1996) model as the basic model structure. As discussed in Chapter 2, the model used by Dhuyvetter et al. (1996) is derived from Ladd and Martin's (1976) input characteristics model and the further developed model by Parcell, Schroeder, and Hiner (1995) which states that

$$r_i = \sum_j T_j x_{ji}$$

where *i* refers to the individual bull; *j* refers to physical, genetic and performance characteristics of the bull; T_j is the marginal implicit price paid for the *j*th characteristic; x_{ji} is the quality of characteristic *j* the bull possesses.

Dhuyvetter et al.'s (1996) analysis of beef bull price differentials splits bull characteristics into two categories and then adds a third. The two categories discussed by Parcell, Schroeder, and Hiner (1995) are physical and genetic characteristics, and expected performance characteristics. The third category that Dhuyvetter et al. (1996) adds to the Parcell, Schroeder, and Hiner (1995) study is marketing factors. He defines the bull price function as follows.

$$\text{Bull Price}_i = f(\text{Physical and Genetic Characteristics}_i, \text{Expected Performance Characteristics}_i, \text{Marketing Factors}_i).$$

Chovosta et al. (2001) included a feed price and beef price factors as part of the bull price function. Due to the nature of the data used we determined that we were working with a shorter time period and less variation in feed costs and beef prices. Expected feed costs and beef prices will be the same for all bull lots sold on the same day. However because we are dealing with five different auctions spanning two and one-half years, each auction will be assigned a dummy variable in order to account for time specific market conditions like feed costs and beef prices.

This study differentiates itself from previous studies because the physical, genetic, and performance characteristics, and marketing factors included are more extensive. Additional differentiation arises due to the newness of the data and the fact that it was gathered from one producer of beef breeding bulls rather than consignment sales where bulls are gathered from multiple producers. Because the data are from one producer with sophisticated data collection procedures, the data are thought to be very consistent across animals and measurement error is minimized. Due to the differentiation and consistency of the data we will include many of the same factors included in the previous studies, but will also add additional factors that previous studies have not included.

Physical and genetic characteristics that have been part of previous studies include, age, conformation, and muscling. This study includes all of the above characteristics with the exception of conformation. The bull data in this study are all gathered from one producer of beef breeding bulls; therefore, the conditioning of the bulls is assumed to be similar for all bulls. Muscling and conformation can be determined from other physical and genetic characteristics. Additional physical and genetic characteristics included in this study are weaning weight, yearling weight, percent intramuscular fat, rib eye area, and scrotal circumference.

Expected performance characteristics, otherwise referred to as expected progeny differences (EPD's), included in previous studies are birth weight EPD, weaning weight EPD, and milk EPD. The additional EPD data used in this study includes, yearling weight EPD, scrotal circumference EPD, rib eye area EPD, percent intramuscular fat EPD, and fat EPD. The EPD data included in this study are breed specific. Due to the fact that each breed develops its own EPD's, therefore the EPDs are not comparable between breeds.

Dhuyvetter et al. (1996) attempted to show how much new information was provided to the buyers through the use of EPDs. To do this they ran the model using just the physical weights and then ran it again with the EPD information. In this study we will test the significance of EPDs in a group to determine whether they are significant in the model. If they are determined to be significant then they provide additional information that is important to the buyer of purebred beef breeding bulls.

Marketing factors have also been included in previous studies. The marketing factors that have been previously considered are selling order, picture, and either retained possession, semen rights or both. Due to the extensive nature of the data that we have been able to collect on the buyers of the bulls we will be able to consider additional marketing factors that previous studies were not able to examine. These additional factors include the use of volume discounts, show winnings, and recommendations for use on heifers.

Data Selection

The data used for this study was accumulated and provided using auction records of Express Ranches in Yukon, Oklahoma. Express Ranches owns and operates two purebred beef herds. They originally began their involvement in purebred beef production in the early 1990's when they purchased 52 fullblood Limousin cows and 180 acres of land. In 1996 Express Ranches added their Express Angus herd. Currently Express Ranches includes over 4000 head of Angus and Limousin cattle, 20,000 acres of land, and annual sales of cattle, semen, and embryo's that exceed $4.5 million (Squires, 2004). Express Ranches primarily markets cattle in their own production sales as well as by private treaty. In excess of 900 bulls are marketed annually through their two bull sales, as well as by private treaty. The large majority of the bulls sold have been through their two bull sales, which are run as English style auctions. Express Ranches holds their spring auction in March and their fall auction in October. The spring sale has consistently been their largest of the two auctions. Express Ranches has consistently provided a great deal of presale information to their prospective buyers through the use of an auction catalog. This information consists of physical and genetic characteristics (including ultrasound carcass data), EPD's and marketing factors. Additionally they have followed up the presale information with more timely information that is available in a catalog supplement provided on the day of the auction. Express Ranches then retains information on each of the bulls auctioned and the buyer of each particular bull.

The data for this study has been accumulated from five of Express Ranches bull auctions. The first auction in the study took place on March 8th and 9th, 2002. The auction consisted of 121 Limousin bulls, 270 Angus bulls. The second auction took place on October 7, 2002. This auction consisted of 131 Angus bulls and 64 Limousin bulls as well as 250 Angus heifers. The third auction took place on March 7th and 8th, 2003. This auction consisted of 301 Angus bulls, 132 Limousin bulls and 155 commercial Angus heifers. The fourth auction took place on October 6th, 2003. This auction offered 154 Angus bulls, 55 Limousin bulls and 250 commercial Angus heifers. The fifth and final auction took place on March 5th, 2004. This auction offered 350 Angus bulls, 100 Limousin bulls and 100 Angus females. Data collected from these five sales provided this study with 1128 Angus bull observations. Data on the Limousin bulls were also collected but will not be used in this study. Due to missing values in the data, 119 observations were dropped giving us 1009 observations.

Type of Auction

Express Ranches holds their auctions using the traditional English open outcry auction style. Paul Milgrom defines the English auction in the following way. "Here the auctioneer begins with the lowest acceptable price – the reserve price- and proceeds to solicit successively higher bids from the customers until no one will increase the bid. The item is 'knocked down' (sold) to the highest bidder (Milgrom, 1989, 7)." In theory this should determine the fair market value for the bull that is being sold. Express Ranches has included numerous incentives for the buyers in order to increase the final or winning bids. These incentives include volume discounts, delivery discounts, and insurance discounts. Every bull that is sold in the auction has the option to be delivered free of charge to the buyer, as well as each buyer has the opportunity to buy breeding insurance on a bull for one year with Express Ranches paying half of the cost. Express Ranches offers a 10 percent volume discount on the total invoice to buyers that purchase 10 or more bulls. This study estimates the effect of the volume discount on the winning bids of the bulls purchased, in particular the bulls that were the tenth or greater purchased by a particular buyer.

Explanation of Variables and Expected Signs

The 26 variables that are used to explain variation in the winning bid for each individual bull are shown in Table III-1. Table III-1 also includes a description, the mean, standard deviation, and expected sign of variables that are considered in this study.

Dhuyvetter et al. (1996) determined that bull price is non-linearly related to age. Young bulls will be discounted due to their immaturity and inability to service as large a number of females as older bulls. As the age of bulls increases the discount associated with the lack of maturity decreases and then levels out. As a bull becomes too old to continue servicing females the discount will again begin to increase. Closely associated with age of bulls is adjusted yearling scrotal circumference. A bull with a larger adjusted yearling scrotal circumference exhibits greater reproductive efficiency and earlier maturity than a bull with a smaller adjusted yearling scrotal circumference, and accordingly should have a positive correlation to the price paid for the bull.

Actual birth weight, and birth weight EPD, are both measurements of how large each bull's offspring will be at birth. Usually larger offspring create a greater probability for dystocia (birthing problems). However light calves can also have abnormal health problems. None of the bulls in these auctions were deemed to produce offspring considered “too” light and the price paid for the calves is expected to be inversely related to birth weight measures.

Table III-1 Angus Variables and the Associated Expected Signs

Variable		Description	Expected Sign
Physical and Genetic Characteristics			
	Age in Days	Age of bull on date of sale in days	+/-
	Adj. Yrlig SC	Bulls Scrotal Circumference adjusted to 365 days	+
	Act. BW	Actual Birth Weight	-
	Adj. WW	Weaning Weight Adjusted to an age of 205 days	+
	Adj. YW	Yearling Weight Adjusted to an age of 365 days	+
	Adj. IMF	Adjusted Intramuscular Fat	+
	Adj. REA	Adjusted Rib Eye Area	+
Expected Progeny Differences			
	Birth EPD	Birth Weight EPD	-
	Weaning EPD	Weaning Weight EPD	+
	Milk EPD	Milk EPD	+
	Yearling EPD	Yearling Weight EPD	+
	%IMF EPD	% Intramuscular Fat EPD	+
	REA EPD	Rib Eye Area EPD	+
	Fat EPD	Fat Thickness EPD	-
	%RP EPD	% Retail Product EPD	+
Marketing Factors			
	Sale Order	Order in which bulls sold in auction	-
	Picture	1 if pictured in catalog, zero if otherwise	+
	Recommended for Heifers	1 if bull was Recommended for Heifers in catalog, zero if otherwise	+
	Shows	1 if bull participated in a show, zero if otherwise	+
	Retention	Percentage of retained semen interest	+
	# of Auctions Purchased Bull	Number of Auctions in which Buyer purchased bulls	+
	# Bulls purchased (Auction Specific)	Number of bulls Buyer purchased each Auction	+
	Bulls Purchased >=10	1 if bull purchased was tenth or greater bull bought buy customer, zero if otherwise	+
	Customer Purchased >=10	1 if customer purchased 10 or more bulls, zero if otherwise	+

Price paid for the purebred beef breeding bull is expected to be positively related to adjusted weaning weight, adjusted yearling weight, as well as weaning weight EPD and yearling weight EPD. Typically the greater the growth of the bull the greater growth characteristics the bulls offspring will exhibit, which to beef producers means a greater quantity of marketable product.

The price paid for the purebred beef breeding bull is expected to be positively related to the carcass quality measures such as adjusted percent intramuscular fat, adjusted rib eye area, percent intramuscular fat EPD, rib eye area EPD, and percent retail product EPD. As these measures increase the perceived quality of meat produced from the bull's offspring increases. The price paid for the purebred beef breeding bull is expected to be negatively related to fat EPD. Large amounts of fat will be trimmed off of the final meat product and used for the production of less profitable products.

Many marketing factor's specific purpose is to increase the price paid for the bull. Pictures are included in the catalog to promote bulls that the seller views as superior to the other bulls in the auction, therefore we expect the inclusion of a picture to have a positive effect on the price paid for bulls. The price paid for purebred beef breeding bulls is expected to be positively related to additional factors such as retention of semen rights and participation in livestock shows, because it gives the bull buyers the perception that these bulls are of superior quality to those bulls not being retained or exhibited. The price paid for a bull has been shown in past studies to be negatively related to sale order. We expect this to remain true in this study as well.

Two other marketing factors that this study will examine are the effect that the number of auctions in which an individual buyer has purchased bulls, and the number of bulls each buyer purchased in one auction.

The number of auctions in which an individual has purchased bulls and number of bulls each buyer purchased in one auction are attempts to measure buyer experience, as well as repeat buyers. These two aspects of buyer psychology conflict with each other. One would say that the more experienced a buyer is, the lower the incidence of “winner's curse” (paying more for an item than its value). This seems to be common in English type auctions because inexperienced participants bid up the price (Reynolds 1996) thus having a negative effect on the price paid. On the other hand, a satisfied repeat buyer would tend to pay more for a bull based on a prior relationship with the seller therefore having a positive effect on the price paid.

The last marketing factor that this study will examine is the volume discount offered to buyers that purchase more than 10 bulls. The presence of a discount should influence buyers to purchase more bulls thus increasing the competition for each bull being sold. In order to do this we set up two variables. The first variable tells us whether the bull purchased was greater or equal to the tenth bull purchased by the same buyer. This tells us whether or not the bull was eligible for the volume discount. The second variable evaluates whether the customer purchased ten or more bulls at that particular auction. This illustrates whether or not the customers who qualify for the volume discount pay more for the bulls that they purchase. It is expected that both the price paid for a purebred beef breeding bull will be positively related to whether the bull was the tenth or greater bull purchased by the same buyer, and whether the customer purchased ten or more bulls at that particular auction.

Summary of Data

Table III-2 shows summary statistics for each of the variables being examined in this study. Looking at the sale order variable we know that there is an average of 251 bulls being sold at each auction. Further examination of the summary statistics we can see that 22 percent of the bulls sold in the Spring 2002 auction, 11 percent in Fall 2002, 25 percent in Spring 2003, 13 percent in Fall 2003, and 30 percent in the Spring 2003 auction. This also shows us that the spring auctions are twice as large as the fall auctions, but each auction is growing in size year to year.

The average age of the bulls in these auctions is just over one year, about 16 months of age, with a standard deviation of just under 3 months. Sixteen percent of the bulls sold had pictures in the catalog, 42 percent were recommended for use on heifers, 11 percent participated in livestock shows, and the seller retained semen interest in 4 percent of the bulls sold.

A few key characteristics are measured and reported in the catalog as additional information to the potential buyers. Adjusted yearling scrotal circumference measures the circumference of a bull's scrotum in centimeters. This has been shown to be an indicator of reproductive efficiency. The average scrotal circumference of the bulls in this auction was 37.35 cm.

Table III-2. Descriptive Statistics for the Variables in the Hedonic Model for Purebred Beef Bulls.

Variable	Mean	Standard Deviation	MAD
Sale Order	125.54	85.26	93.4039
Auction 1	0.22	.	.
Auction 2	0.11	.	.
Auction 3	0.25	.	.
Auction 4	0.13	.	.
Auction 5	0.30	.	.
Age in Days	494.45	89.77	121.6
Picture	0.16	.	.
Recommended for Heifers	0.42	.	.
Shows	0.11	.	.
Retention	0.04	.	.
Adj. Yrlig SC	37.35 cm	2.24 cm	2.3722 cm
Act. BW	79.06 lbs	9.37 lbs	8.8956 lbs
Adj. WW	711.51 lbs	87.01 lbs	85.9909 lbs
Adj. YW	1213.70 lbs	107.82 lbs	115.6 lbs
Adj. IMF	3.60%	0.80%	0.6820%
Adj. REA	13.63 in^2	1.53 in^2	1.3343 in^2
Birth EPD	2.48 lbs	1.60 lbs	1.4826 lbs
Weaning EPD	38.58 lbs	6.16 lbs	5.9304 lbs
Milk EPD (calf lbs @ weaning)	21.00 lbs	4.29 lbs	4.4478 lbs
Yearling EPD	47.84 lbs	10.32 lbs	10.3782 lbs
%IMF EPD	0.078%	0.161%	0.1631%
REA EPD	0.148 in^2	0.202 in^2	0.2076 in^2
Fat EPD	0.003 in	0.017 in	0.0163 in
%RP EPD	0.049%	0.299%	0.2965%
# of Auctions Purchased Bull	1.28	0.56	0
# Bulls purchased (Auction Specific)	4.24	5.87	1.4826
Bulls Purchased >=10	0.10	.	.
Customer Purchased >=10	0.27	.	.
Winning Bid	$3171.96	$2335.70	$741.3

Weight and carcass measures are expressed as actual/adjusted and expected progeny difference (EPD). The actual/adjusted weight measures refer to the individual bull. So the average bull in these auctions was born at 79.06 lbs, has an adjusted weaning weight (205 day weight) of 711.51 lbs an adjusted yearling weight (365 day weight) of 1213.70 lbs, a 3.60 percent adjusted intramuscular fat (adjusted to 365 days), and a 13.63 square inch Rib eye area (adjusted to 365 days).

EPD measures convey how the offspring of the bulls are expected to perform compared to the offspring of other bulls. The birth weight EPD “is expressed in pounds different from the average. A bull with a birth weight EPD of –2.5 should sire calves 2.5 lbs. lighter than the average bull of that breed (Express Catalog, 2002).” Weaning weight and yearling weight EPD’s “are used to express growth and the growth that bull will transmit to his offspring. A bull with a +40 EPD for weaning weight compared to a bull with a +30 for weaning weight should sire calves that are 10 pounds heavier at weaning (Express Catalog, 2002).” “The milk EPD is expressed as pounds of weaning weight that will result from the amount of milk produced by daughters of a particular sire. A bull with a +20 EPD for milk should sire daughters that will have calves that are 10 pounds heavier at weaning than a sire with a milk EPD of +10 (Express Catalog, 2002).” The intramuscular fat EPD is a “predictor of the difference in a sire's progeny for percent intramuscular fat in the rib eye muscle compared to other sires (American Angus Association, 2004).” A bull with a 0.20 EPD for percent intramuscular fat compared to a bull with a 0.10 for percent intramuscular fat should sire calves that have a 0.10 percent greater intramuscular fat in the rib eye muscle. The rib eye area EPD is a “predictor of the difference in square inches of rib eye area of a sire's progeny compared to the progeny of other sires (American Angus Association, 2004).” A bull with a 0.20 EPD for rib eye area compared to a bull with a 0.10 for rib eye area should sire calves that have a 0.10 square inch greater rib eye area. The fat EPD “expressed in inches is a predictor of the difference in external fat thickness at the 12th rib of a sire's progeny compared to the progeny of other sires. It includes the weighted average of 60 percent of the rib fat measurement and 40 percent of the rump fat measurement (American Angus Association, 2004)." A bull with a 0.020 EPD for fat compared to a bull with a 0.010 for fat should sire calves that have a 0.010 inch greater weighted average fat measurement. The retail product EPD "is a predictor of the difference in percent pounds of salable retail product of a sire's progeny compared to the progeny of other sires (American Angus Association, 2004)". A bull with a 0.20 EPD for percent retail product compared to a bull with a 0.10 for percent retail product should sire calves that have a 0.10 percent pounds of salable retail product.

The average bull in these auctions has a birth weight EPD of 2.48 lbs., weaning weight EPD of 38.58 lbs., yearling weight EPD of 47.84 lbs., milk EPD of 21.00 lbs percent intramuscular fat EPD of 0.078 percent, rib eye area EPD 0.148 square inch, fat EPD of 0.003 lbs. and percent retail product EPD of 0.049 percent.

From the summary statistics we can determine that 10 percent of the bulls purchased in the sale were either the tenth or higher bull purchased from the same buyer at that auction. We can also deduce that 27 percent of the bulls purchased in these auctions were bought by buyers that bought ten or more bulls at that auction, thus qualifying them for the ten percent discount.

The average bull in these five auctions sold for $3,171.96 with a standard deviation of $2,335.70.

These summary statistics tell us a great deal about the bulls in the auctions, but they can also tell us some things about the buyers at these auctions. Almost one third of the buyers of bulls that purchased a bull had previously purchased a bull before and the average number of bulls purchased by a single buyer is 4.24 bulls.

CHAPTER IV

STATISTICAL MODELS, RESULTS AND INTERPRETATION

The Empirical Models

Previous research has found that the relationship between bull prices and bull characteristics is not linear. Four different functional forms are used to determine the value associated with each characteristic and its effect on a purebred beef breeding bull's final winning bid. Linear and quadratic models are estimated with both an untransformed dependant variable and a logarithmic transformation of the dependant variable. These models are estimated using the 26 variables found in Table III-1. The continuous independent variables are squared in the quadratic models. Below are the models estimated in determining the value associated with each characteristic and its effect on a purebred beef breeding bull's final winning bid

The linear model is simply written as

$$\text{Winning Bid}_i = f(\text{Physical and Genetic Characteristics}_i, \text{Expected Progeny Differances, Marketing Factors}_i).$$

The quadratic model is obtained by squaring the continuous independent variables from the linear model. This equation is written as

Winning $Bid_i = f$(Physical and Genetic $Characteristics_i$, Expected Progeny $Differances_i$, Marketing $Factors_i$ Physical and Genetic $Characteristics_i^2$, Expected Progeny $Differances_i^2$, Marketing $Factors_i^2$).

To achieve the exponential model we used a logarithmic transformation of the dependant variable, winning bid. This equation can be written as

Log Winning $Bid_i = f$(Physical and Genetic $Characteristics_i$, Expected Progeny Differances, Marketing $Factors_i$).

Combined Exponential Quadratic combined the logarithmic transformation of the dependant variable, winning bid, as well as making it a function of variables and variables squared. This equation can be written as

Log Winning $Bid_i = f$(Physical and Genetic $Characteristics_i$, Expected Progeny $Differances_i$, Marketing $Factors_i$ Physical and Genetic $Characteristics_i^2$, Expected Progeny $Differances_i^2$, Marketing $Factors_i^2$).

These four functional forms are first estimated using ordinary least squares and the residuals are tested for normality using the Shapiro-Wilk, Kolmogorov-Smirnow and the Anderson-Darling tests.

The results of the ordinary least squares estimates as well as the normality tests are found in Tables IV-1 through IV-4. In each case, normality tests suggest that the residuals are not normally distributed. These auctions included some exceptional bulls that sold for extraordinarily high prices. These observations have been checked for validity in addition to importance and found to be legitimate as well as valuable.

Table IV-1. Linear Model Parameter Estimates for the Hedonic Model for Purebred Beef Bulls

Variable	Estimated Parameter	Test Statistic
Sale Order	-5.69704	-4.75***
Auction 2	-576.50151	-1.78**
Auction 3	-275.01481	-1.46*
Auction 4	-317.73571	-1.18
Auction 5	538.34009	2.69***
Age in Days	4.51745	3.50***
Picture	152.34009	0.49
Recommended for Heifers	567.31628	3.35***
Shows	309.68077	0.94
Retention	6437.28937	7.14***
Adj. Yrlig SC	20.56429	0.69
Act. BW	4.06044	0.54
Adj. WW	1.83929	1.82**
Adj. YW	-0.27400	-0.28
Adj. IMF	317.32946	2.86***
Adj. REA	309.90726	5.31***
Birth EPD	-79.09342	-1.19
Weaning EPD	-6.90786	0.35
Milk EPD	7.40080	0.47
Yearling EPD	20.29562	1.65
%IMF EPD	133.32052	2.05***
REA EPD	35.61352	0.06
Fat EPD	-12903	-1.93**
%RP EPD	-432.90397	-0.86
# of Auctions Purchased Bull	-44.87499	-0.41
# Bulls purchased (Auction Specific)	-7.05215	-0.40
Bulls Purchased >=10	161.49581	0.50
Customer Purchased >=10	-176.01406	-1.01

Normality Tests	Shapiro-Wilk	0.528957	<0.0001
	Kolmogorov-Smirnov	0.207981	<0.0100
	Anderson-Darling	91.64487	<0.0050

***Significant to the 0.01 level
**Significant to the 0.05 level
*Significant to the 0.10 level

Table IV-2. Linear with Squared Variables Model Parameter Estimates for the Hedonic Model for Purebred Beef Bulls

Variable	Estimated Parameter	Test Statistic
Sale Order	-21.48620	-6.06***
Auction 2	-823.18488	-2.08**
Auction 3	-172.16743	-0.92
Auction 4	-584.27715	-2.04**
Auction 5	339.24251	1.66**
Age in Days	21.85626	2.27**
Picture	-2.23347	-0.01
Recommended for Heifers	691.52310	4.10***
Shows	340.50963	1.05
Retention	5333.24027	5.91***
Adj. Yrlig SC	-42.31827	-0.07
Act. BW	3.39340	0.05
Adj. WW	4.95851	0.53
Adj. YW	7.65653	0.70
Adj. IMF	109.36773	0.23
Adj. REA	-570.40055	-2.92***
Birth EPD	-26.87424	-0.20
Weaning EPD	-154.99312	-1.28
Milk EPD	133.97752	1.45*
Yearling EPD	-8.25639	-0.10
%IMF EPD	-516.39755	-0.68
REA EPD	277.07101	0.39
Fat EPD	-8668.40995	-1.27
%RP EPD	-211.77227	-0.42
# of Auctions Purchased Bull	498.37011	0.71
# Bulls purchased (Auction Specific)	33.79610	0.86
Bulls Purchased >=10	124.44695	0.38
Customer Purchased >=10	-399.15436	-2.10**
Sale Order2	0.05109	5.03***
Age in Days2	-0.01711	-1.77**
Adj. Yrlig SC2	0.87642	0.10
Act. BW2	-0.01646	0.04
Adj. WW2	-0.00273	-0.42
Adj. YW2	-0.00294	-0.66
Adj. IMF2	14.33636	0.24
Adj. REA2	24.68159	4.66***
Birth EPD2	3.41497	0.14
Weaning EPD2	2.07944	1.31
Milk EPD2	-2.92712	-1.34*
Yearling EPD2	0.12527	0.22

Table IV-2. Linear with Squared Variables Model Parameter Estimates for the Hedonic Model for Purebred Beef Bulls

Variable	Estimated Parameter	Test Statistic
%IMF EPD2	7141.09194	3.50***
REA EPD2	1315.80046	1.15
Fat EPD2	63885	0.43
%RP EPD2	-438.29644	-0.84
# of Auctions Purchased Bull2	-156.26722	-0.80
# Bulls purchased (Auction Specific)2	-0.73808	-0.77

Normality Tests	Shapiro-Wilk	0.523084	<0.0001
	Kolmogorov-Smirnov	0.225523	<0.0100
	Anderson-Darling	87.89848	<0.0050

***Significant to the 0.01 level
**Significant to the 0.05 level
*Significant to the 0.10 level

Table IV-3. Exponential Model Parameter Estimates for the Hedonic Model for Purebred Beef Bulls

Variable	Estimated Parameter	Test Statistic
Sale Order	-0.00212	-12.82***
Auction 2	-0.03627	-0.81
Auction 3	0.06300	2.43**
Auction 4	-0.02986	-0.8
Auction 5	0.26016	9.43***
Age in Days	0.00053770	3.03***
Picture	0.10224	2.39**
Recommended for Heifers	0.10395	4.46***
Shows	-0.01251	-0.28
Retention	0.63660	5.13***
Adj. Yrlig SC	0.00843	2.07**
Act. BW	0.00065276	0.63
Adj. WW	0.00036004	2.59***
Adj. YW	0.00037090	2.75***
Adj. IMF	0.05246	3.43***
Adj. REA	0.04586	5.71***
Birth EPD	-.03302	-3.60***
Weaning EPD	-0.00430	-1.60
Milk EPD	0.00163	-0.76
Yearling EPD	0.00589	3.49***
%IMF EPD	0.25913	2.89***
REA EPD	0.08672	0.99
Fat EPD	-1.85324	-2.01**
%RP EPD	-0.04430	-0.64
# of Auctions Purchased Bull	-0.01671	-1.10
Bulls Purchased >=10	-0.00125	-0.51
Customer Purchased >=10	0.02912	0.66
# Bulls purchased (Auction Specific)	0.00292	0.12

Normality Tests	Shapiro-Wilk	0.913821	<0.0001
	Kolmogorov-Smirnov	0.075899	<0.0100
	Anderson-Darling	13.63775	<0.0050

***Significant to the 0.01 level
**Significant to the 0.05 level
*Significant to the 0.10 level

Table IV-4. Exponential with Squared Variables Model Parameter Estimates for the Hedonic Model for Purebred Beef Bulls

Variable	Estimated Parameter	Test Statistic
Sale Order	-0.00530	-10.94***
Auction 2	-0.12185	-2.25**
Auction 3	0.06967	2.72***
Auction 4	-0.10144	-2.59***
Auction 5	0.22086	7.92***
Age in Days	0.00255	1.94**
Picture	0.05782	1.36*
Recommended for Heifers	0.12001	5.20***
Shows	-0.00636	-0.14
Retention	0.45097	3.65***
Adj. Yrlig SC	-0.08725	-1.00
Act. BW	0.00046244	-0.05
Adj. WW	0.00038112	0.30
Adj. YW	0.00122	0.81
Adj. IMF	0.03243	0.50
Adj. REA	-0.01336	-0.50
Birth EPD	-0.01467	-0.80
Weaning EPD	-0.03099	-1.87**
Milk EPD	0.02885	2.28**
Yearling EPD	-0.00151	-0.13
%IMF EPD	0.07828	0.75
REA EPD	0.07422	0.76
Fat EPD	-1.66881	-1.79**
%RP EPD	-0.03765	-0.55
# of Auctions Purchased Bull	0.15687	1.63*
# Bulls purchased (Auction Specific)	0.00762	1.41*
Bulls Purchased >=10	0.02830	0.62
Customer Purchased >=10	-0.03390	-1.30*
Sale Order2	0.00001009	7.26***
Age in Days2	-0.00000187	-1.42*
Adj. Yrlig SC2	0.00129	1.10
Act. BW2	-0.00000368	-0.06
Adj. WW2	-7.50942E-8	-0.08
Adj. YW2	-3.56232E-7	-0.59
Adj. IMF2	0.00101	0.12
Adj. REA2	0.00156	2.16**
Birth EPD2	-0.00153	-0.47
Weaning EPD2	0.00037118	1.71*
Milk EPD2	-0.00063127	-2.11**
Yearling EPD2	0.00003953	0.52
%IMF EPD2	0.69596	2.49***

Table IV-4. Exponential with Squared Variables Model Parameter Estimates for the Hedonic Model for Purebred Beef Bulls

Variable	Estimated Parameter	Test Statistic
REA EPD2	0.30774	1.97**
Fat EPD2	30.19806	1.50*
%RP EPD2	-0.09792	-1.37*
# of Auctions Purchased Bull	-0.04985	-1.87**
# Bulls purchased (Auction Specific)	-0.00018581	-1.42*

Normality Tests	Shapiro-Wilk	0.921984	<0.0001
	Kolmogorov-Smirnov	0.0.72699	<0.0100
	Anderson-Darling	10.58409	<0.0050

***Significant to the 0.01 level
**Significant to the 0.05 level
*Significant to the 0.10 level

"When the errors are distributed normally, the optimal least squares (OLS) estimator in the CLR model is the best unbiased, meaning that among all unbiased estimators it has the smallest variance. Whenever the errors are not distributed normally, a weaker result holds, namely that the OLS estimator is best linear unbiased (BLUE), meaning that among all linear unbiased estimators it has the smallest variance (Kennedy, 1998, 299)."

This holds true unless the distribution of the errors frequently produces relatively large errors, such as is the case when outlier or leverage point observations are present. In this case the OLS estimator though it is best linear unbiased estimate (BLUE) it is substandard to some nonlinear unbiased estimators, otherwise known as robust estimators. Outlier or leverage point observations are also known as influential observations in that they have a strong influence on the OLS estimates.

When these influential observations are identified, they need to be scrutinized to determine, first whether they are influential due to a mistake in measurement, reporting/recording errors, or inaccuracy in data transfer, and second whether these influential observations are legitimate and important. If the influential observations are legitimate and important to the study a robust estimator can be used (Kennedy, 1998).

In the case of this study we are faced with this situation. We have outlier observations that prove to be influential observations and error terms are not normally distributed. Because there are large outliers that contain information that is valuable and accurate, a robust regression, available in Version 9.1 of SAS (SAS Institute) is used.

"The main purpose of robust regression is to detect outliers and provide resistant (stable) results in the presence of outliers. In order to achieve this stability, robust regression limits the influence of outliers (SAS Institute)." This study will use the robust regression procedure using the M estimation method, developed by Huber (1973). It is the "simplest approach both computationally and theoretically (SAS)."

The M estimator process is similar to the OLS process with the exception of one thing, OLS minimizes a weighted sum of absolute errors where the weight is the absolute error, thus we minimize the sum of squared errors. This causes the outlier or influential observations to grow in magnitude or importance, thus increasing the normality problem. The M estimator process uses weights other than the absolute error. These weights do not continue to grow as the absolute value of errors grows.

The following sections will discuss the robust nonlinear unbiased estimator models that correspond with the ordinary least squares models previously discussed. The robust models that will be discussed in the following sections are the robust linear, robust quadratic (robust linear with squared variables), robust exponential, and robust exponential quadratic.

Table III-2 contains the results for the mean absolute deviation (MAD), which is a robust estimate of the univariate scale. A large difference in the standard deviation and the MAD indicates that there are large jumps in the observations for that particular variable. Table III-2 suggests that variables Sale Order, Age in Days, Adj. YW, # Bulls purchased (Auction Specific), and Winning Bid have large jumps or outlier observations.

Table IV-5 contains the goodness of fit statistics for the four robust models previously described. As we can see from the table, each of the models are good fits for the data in this study. Due to the transformation of the dependant variable we need to evaluate the two exponential models separately from the linear and quadratic models.

We are comfortable with the explanatory power of each of these models and therefore each of these models could be used to determine the effect that characteristics have on the price paid for bulls.

Table IV-5. Goodness of Fit Statistics for Robust Models

Model	Statistic	Value
Linear		
	R^2	0.4173
	AICR	1467.918
	BICR	1625.925
Quadratic		
	R^2	0.4440
	AICR	1438.489
	BICR	1694.677
Exponential		
	R^2	0.4746
	AICR	1271.796
	BICR	1427.022
Exponential Quadradic		
	R^2	0.4746
	AICR	1271.796
	BICR	1427.022

AICR= Robust version of Aikaike information criteria
BICR= Robust version of Bayesian information criteria

Results and Implications

Each of the four models used to determine the value associated with each characteristic and its effect on a purebred beef breeding bull's final winning bid has good explanatory power. This section, however, will focus on the results of the robust linear model as it exhibits a higher percentage of significant variables. Tables IV-6 through IV-9 contain the results for the all of the robust regression's using the M estimation method. The program code used to obtain the estimates is found in Appendix A.

Table IV-6. Robust Linear Model Estimates and Chi Squares

Variable		Estimate	Chi Squares
Sale Order		-5.4247	289.06***
Auction 2	0	-55.3911	0.41
	1	0	.
Auction 3	0	-349.953	48.76***
	1	0	.
Auction 4	0	31.1622	0.19
	1	0	.
Auction 5	0	-703.216	172.73***
	1	0	.
Age in Days		0.4649	1.84*
Picture	0	-358.163	18.52***
	1	0	.
Recommended for Heifers	0	-61.4095	1.86*
	1	0	.
Shows	0	-236.832	7.34***
	1	0	.
Retention	0	-11889.7	1657.62***
	0.33	-12214.3	1790.58***
	0.50	0	.
Adj. Yrlig SC		17.9104	5.17***
Act. BW		1.4934	0.56
Adj. WW		0.8655	10.36***
Adj. YW		1.0094	14.97***
Adj. IMF		49.1035	2.76**
Adj. REA		88.2458	32.36***
Birth EPD		-115.701	42.65***
Weaning EPD		-11.1703	4.63**
Milk EPD		5.5538	1.77*
Yearling EPD		11.8039	13.07***
IMF EPD		699.0227	16.27***
REA EPD		237.1637	1.97*
Fat EPD		-3151.44	3.13**
%RP EPD		-105.235	0.62
# of Auctions Purchased Bull		-43.6957	2.21*
# Bulls purchased (Auction Specific)		-0.3584	0.01
Bulls Purchased >=10	0	1.6517	0
	1	0	.
Customer Purchased >=10	0	-39.6816	2.27*
	1	0	.

***Significant to the 0.01 level
**Significant to the 0.05 level
*Significant to the 0.10 level

Table IV-7. Robust Quadratic Model Estimates and Chi Squares

Variable		Estimates	Chi Squares
Sale Order		-11.3956	144.66***
Auction 2	0	137.7343	1.69*
	1	0	.
Auction 3	0	-359.197	51.27***
	1	0	.
Auction 4	0	201.3549	6.91***
	1	0	.
Auction 5	0	-642.694	137.77***
	1	0	.
Age in Days		5.5075	4.58**
Picture	0	-292.748	12.31***
	1	0	.
Recommended for Heifers	0	-121.062	7.2***
	1	0	.
Shows	0	-150.131	3.01**
	1	0	.
Retention	0	-11789.4	1700.73***
	0.33	-12267	1886.28***
	0.50	0	.
Adj. Yrlig SC		-99.106	0.33
Act. BW		3.0553	0.03
Adj. WW		-0.7239	0.08
Adj. YW		-0.6643	0.05
Adj. IMF		316.6957	6.24***
Adj. REA		-799.602	234.92***
Birth EPD		-107.088	8.96***
Weaning EPD		12.7308	0.15
Milk EPD		31.8404	1.65*
Yearling EPD		-10.0365	0.20
%IMF EPD		399.0307	3.82**
REA EPD		117.0541	0.37
Fat EPD		-624.699	0.12
%RP EPD		39.5519	0.09
# of Auctions Purchased Bull		352.5693	3.52**
# Bulls purchased (Auction Specific)		28.0722	7.07***
Bulls Purchased >=10	0	31.5876	0.13
	1	0	.
Customer Purchased >=10	0	31.1092	0.37
	1	0	.
Sale Order2		0.0180	43.88***
Age in Days2		-0.0045	2.99**
Adj. Yrlig SC2		1.5445	0.46
Act. BW2		-0.0161	0.02

Table IV-7. Robust Quadratic Model Estimates and Chi Squares

Variable	Estimates	Chi Squares
Adj. WW2	0.0010	0.36
Adj. YW2	0.0007	0.32
Adj. IMF2	-36.4146	5.18**
Adj. REA2	33.1239	547.67***
Birth EPD2	4.6147	0.52
Weaning EPD2	0.0307	0.01
Milk EPD2	-0.6652	1.29
Yearling EPD2	0.1404	0.89
%IMF EPD2	1633.95	8.96***
REA EPD2	-322.811	1.12
Fat EPD2	2957.127	0.01
%RP EPD2	-120.338	0.74
# of Auctions Purchased Bull2	-114.427	4.81**
# Bulls purchased (Auction Specific)2	-0.6034	5.60***

***Significant to the 0.01 level
**Significant to the 0.05 level
*Significant to the 0.10 level

Table IV-8. Robust Exponential Model Estimator and Chi Squares

Variable		Estimate	Chi Squares
Sale Order		-0.0021	286.70***
Auction 2	0	0.0176	0.27
	1	0	.
Auction 3	0	-0.1394	50.49***
	1	0	.
Auction 4	0	0.0090	0.10
	1	0	.
Auction 5	0	-0.2858	186.25***
	1	0	.
Age in Days	0	0.0003	4.14**
Picture	0	-0.0724	4.94**
	1	0	.
Recommended for Heifers	0	-0.0450	6.52***
	1	0	.
Shows	0	-0.0011	0.00
	1	0	.
Retention	0	-1.3766	145.05***
	0.33	-1.3469	142.14***
	0.5	0	.
Adj. Yrlig SC		0.0073	5.62***
Act. BW		0.0006	0.53
Adj. WW		0.0004	13.21***
Adj. YW		0.0004	15.31***
Adj. IMF		0.0307	7.03***
Adj. REA		0.0319	27.62***
Birth EPD		-0.0442	40.66***
Weaning EPD		-0.0046	5.06**
Milk EPD		0.0023	1.91
Yearling EPD		0.0057	19.84***
%IMF EPD		0.2119	9.77***
REA EPD		0.1060	2.56*
Fat EPD		-1.486	4.55**
%RP EPD		-0.0518	0.99
# of Auctions Purchased Bull		-0.0204	3.15**
# Bulls purchased (Auction Specific)		-0.0006	0.11
Bulls Purchased >=10	0	-0.019	0.32
	1	0	.
Customer Purchased >=10	0	-0.0270	2.22*
	1	0	.

***Significant to the 0.01 level
**Significant to the 0.05 level
*Significant to the 0.10 level

Table IV-9. Robust Exponential Quadratic Model Estimates and Chi Squares

Variable		Estimate	Chi Squares
Sale Order		-0.0044	138.23***
Auction 2	0	0.0557	1.79*
	1	0	.
Auction 3	0	-0.1465	55.13***
	1	0	.
Auction 4	0	0.0676	5.03**
	1	0	.
Auction 5	0	-0.2655	152.03***
	1	0	.
Age in Days		0.0016	2.37*
Picture	0	-0.0402	1.50
	1	0	.
Recommended for Heifers	0	-0.0595	11.27***
	1	0	.
Shows	0	0.0096	0.08
	1	0	.
Retention	0	-1.3166	137.16***
	0.33	-1.3288	173.13***
	0.5	0	.
Adj. Yrlig SC		-0.0599	0.79
Act. BW		0.0032	0.19
Adj. WW		-0.0005	0.23
Adj. YW		0.0006	0.31
Adj. IMF		0.0734	2.17*
Adj. REA		-0.0345	2.83**
Birth EPD		-0.0403	8.22***
Weaning EPD		-0.0127	0.99
Milk EPD		0.0148	2.30*
Yearling EPD		-0.0057	0.42
%IMF EPD		0.1758	4.79**
REA EPD		-0.0822	1.19
Fat EPD		-1.1069	2.37*
%RP EPD		-0.0285	0.39
# of Auctions Purchased Bull		0.1615	4.77**
# Bulls purchased (Auction Specific)		0.0078	3.57*
Bulls Purchased >=10	0	-0.0181	0.27
	1	0	.
Customer Purchased >=10	0	0.0024	0.01
	1	0	.
Sale Order2		0	41.46***
Age in Days2		0	1.2
Adj. Yrlig SC2		0.0090	1.01
Act. BW2		0	0.17

Table IV-9. Robust Exponential Quadratic Model Estimates and Chi Squares

Variable	Estimate	Chi Squares
Adj. WW2	0	0.73
Adj. YW2	0	0.06
Adj. IMF2	0.0061	0.94
Adj. REA2	0.0023	17.09***
Birth EPD2	0.0009	0.12
Weaning EPD2	0.0001	0.47
Milk EPD2	-0.0003	1.736*
Yearling EPD2	0.0001	1.510*
%IMF EPD2	0.1959	0.83
REA EPD2	0.0698	0.34
Fat EPD2	7.8377	0.26
%RP EPD2	-0.0213	0.15
# of Auctions Purchased Bull	-0.0514	6.27***
# Bulls purchased (Auction Specific)	0.0002	3.54**

***Significant to the 0.01 level
**Significant to the 0.05 level
*Significant to the 0.10 level

Significance tests were computed for subgroups called Auction, Actual/Adjusted performance measures, and EPD measures. To determine significance robust versions of Wald tests and F-tests were conducted. Table IV-10 shows the results of the Wald and F-tests. The robust Wald tests determined that each of these categories were significant to the 0.01 level. The robust F-tests found that Auctions, and the actual/adjusted performance measures were significant to the 0.01 level, and the EPD measures were found to be significant at a 0.05 level. For this study we are going to use the robust version of the Wald test and estimate the models using each of the three subcategories.

Table IV-10. Robust Linear Model Test Statistics for Significance of Auctions, Act/Adj., EPD, Est. EPD

	Test	Test Statistic	Lambda	DF	Chi^2	Pr> Chi^2
Auction						
	Rho	42.6269	0.7977	4	53.44	<0.0001***
	R_n^2	219.6142		4	219.31	<0.0001***
Actual/Adjusted Measures	Rho	18.5155	0.7977	6	23.21	0.0006***
	R_n^2	159.6741		6	159.67	<0.0001***
EPD Measures						
	Rho	12.1392	0.7977	8	15.22	0.1963**
	R_n^2	125.9416		8	125.94	<0.0001***

***Significant to the 0.01 level
**Significant to the 0.05 level
Rho= Robust version of the F-Test also known as a ρ -test
R_n^2= Robust version of Wald test.

Out of the 28 variables examined in the robust linear regression 23 express significance to at least the 0.10 level. The variables that did not exhibit any level of significance were auction 2, auction 4, actual birth weight, milk EPD, % retail product

EPD, number of bulls purchased, and bulls purchased greater or equal to ten. However, auction 2, auction 4, milk EPD, and number of auctions a buyer has purchased a bull demonstrate significance at least one of the other models.

Marketing factors have a definite effect in the price paid for purebred beef breeding bulls. As has been found in studies by Dhuyvetter et al. (1996), Minert et al. (1990), and Schroeder et al. (1988), this study found that price is negatively correlated with the order in which a bull was sold in the auction. It was found that for every bull sold there is a decrease in the next bull sold of over $5.42.

There is a difference in the auctions from year-to-year. This can be associated with the feed price, meat price, or other market conditions that change from year to year. It may also be related to the time of year and number of bulls in the auction. Using the dummy variables for the five different auctions we are able to determine if there is a shift in the intercept for each auction. The two spring sales (Auctions 3 and 5) were found to be significant in the linear model, and the fall 2002 and 2003 (Auction 2 and 4) were found to be significant in the quadratic model. Relative to the spring 2002 sale, using the quadratic model, the price paid for a purebred beef breeding bull increased in the fall 2002, spring 2003, and spring 2004 auctions, whereas the price was lower in the fall 2003 auction.

Pictures, recommendation for use on heifers, livestock show participation, and the retention of semen are all found to add to the price paid for a purebred beef breeding bull. Bulls that had pictures in the catalog on average brought $358.16 more then those bulls that did not have pictures included in catalog. Those bulls that were recommended for use on heifers were bought for an average of $61.41 more than those bulls that did not receive recommendations. Those bulls that were a part of the sellers show string (a popular term to indicate the animals that participate in livestock shows) on average received $236.83 more than those bulls that did not participate in livestock shows. An extension of this study could be to determine if the practice of livestock show participation adds economic value. Does it costs more than $237 per bull to be involved in shows? The value of showing, however, should also add value to all of the seller's bulls, not just those who participate. When the seller retains a portion of semen rights (either for personal use or for outside marketing) it seems to add great value to the price paid for the bull.

In an attempt to measure the effect that a volume discount offered to the buyers has on the price paid for purebred beef breeding bulls, two variables, bulls bought by customers who purchased ten or more bulls and number of auctions the customer has purchased a bull were found to be significant. The price paid for a purebred beef breeding bull is positively related to whether the bull was bought by a buyer who purchased ten or more bulls. Buyers that were eligible for the volume discount paid on average $69.68 more per bull. What this variable does not capture is the effect that the increased bidding competition had on the entire population of bulls. In order to capture this type of information one would need to know who was the second highest bidder. The price paid for a purebred beef breeding bull is negatively related to the number of auctions the customer has purchased a bull. Buyers that had previously purchased a bull in a prior sale on average paid $43.70 less per bull. This leads us to believe that buyer experience (decreasing the incidence of "winner's curse") may be greater than the effect of being a satisfied repeat buyer.

Price paid for purebred beef breeding bulls is positively and significantly related to all of the individual bulls actual and adjusted performance measures with the exception of the actual birth weight. As hypothesized, price is positively related to adjusted yearling scrotal circumference. Buyers of purebred breeding bulls pay an average of $17.91 per centimeter more for scrotal circumference. Scrotal circumference is shown to be positively correlated with reproductive efficiency and early maturation in cattle. This could lead us to believe that the buyers of bulls are looking for bulls that are both reproductively efficient as well as produce calves that reach maturity early.

Adjusted weaning weight and yearling weights were estimated to have a positive impact on the price paid for a purebred beef breeding bull. This is consistent with previous studies by Chvosta et al. (2001), and Dhuyvetter et al. (1996). Buyers of purebred beef breeding bulls look at these growth indicators and will pay a premium for bulls that have greater weaning and yearling weights.

Perhaps the two most intriguing actual and adjusted performance measures are the two that measure the quantity and quality of the bull's carcass. This seems to be on the forefront of the purebred beef industry. This study is one of the first to examine the effect of carcass measures on the price paid for purebred beef breeding bulls. Intramuscular fat (otherwise known as marbling) has been shown to be positively correlated with consumer perceived meat quality. Beef producers are paid a premium for meat that grades choice or better. Intramuscular fat is one measure that is taken into consideration when grading meat. This study has determined that the price paid for purebred beef breeding bulls is positively related to adjusted intramuscular fat as well as adjusted rib eye area. Buyers will pay a $49.10 more per percent increase in adjusted intramuscular fat and over $88.25 more per square inch of rib eye area. This indicates that buyers of purebred beef breeding bulls are paying attention to carcass information provided to them at auctions.

As mentioned in Chapter 3, EPD measures convey how the offspring of the bulls are expected to perform compared to the offspring of other bulls. EPD's are valuable information for buyers of purebred beef breeding bulls. Of the 8 EPD variables 7 are significant.

The results on birth weight EPD are consistent with the predicted sign shown in Table III-2. The price paid for a purebred beef breeding bull is negatively related with the birth weight EPD. The birth weight EPD shows that buyers will discount the price paid by an average of $115.70 per pound increase in the birth weight EPD. This shows that buyers greatly desire bulls with a lower birth weight EPD.

The price paid for a purebred beef breeding bull is negatively related to weaning weight EPD. This was a surprising and unexpected result. One possible explanation for this result is that the yearling weight EPD is more valuable to buyers of purebred beef breeding bulls than weaning weight EPD. If this is the case a bull that has a low weaning weight EPD but a high yearling weight EPD will bring a premium regardless of the low weaning weight EPD.

Yearling weight EPD has a positive effect on the price paid for a purebred beef breeding bull. Buyers will pay an average of $11.80 per lb increase for yearling weight EPD. This indicates that buyers of purebred beef breeding bulls will pay a premium for bulls that express higher yearling growth.

Again we find interesting results for our carcass EPD's. The percent intramuscular fat EPD has a positive influence on the price paid for a purebred beef breeding bull. This EPD shows that a buyer will pay an average premium of $699.02 more per percent of intramuscular fat located in the rib eye muscle. The differences in percent intramuscular fat EPD is usually in the tenths of a percent. This still translates into a $69.90 increase per tenth of a percent in intramuscular fat located in the rib eye muscle. Buyers seem to be very attentive to the intramuscular fat EPD's and are paying a premium.

The results for rib eye area EPD show a similar result as the percent intramuscular fat EPD. The price paid for a purebred beef breeding bull is positively related to the rib eye area EPD. The rib eye area EPD shows us that buyers will pay a premium of $237.16 per square inch of additional rib eye.

As hypothesized, fat EPD has a negative influence on the price paid for the bull. The fat EPD shows us that buyers of purebred beef breeding bulls will pay $3,151.44 less per inch increase of estimated fat EPD. The differences in fat EPD is usually in hundredths of an inch. However this still translates into a $31.51 discount per one hundredth of an inch increase in fat EPD.

CHAPTER V

SUMMARY AND CONCLUSIONS

This chapter includes a concise review of key points focused on in the previous chapters, implications, final remarks associated with the study objectives, and suggestions with respect to future research.

Summary

"For each product consumed, the price paid for the product equals the sum of the marginal monetary value of the product's characteristics. We measure a product's characteristics in order to measure its quality. In doing this we replace the idea of 'product quality' by 'product qualities' and measure 'qualities' by measuring characteristics (Ladd 1976, 509)." Because each price paid for the product equals the sum of the values associated with it's characteristics, we can examine these key characteristics and their associated values in order to determine the overall value of the product.

Bull prices are determined by genetic, physical, and expected performance characteristics of the bull and their offspring as well as by marketing techniques not necessarily related to the quality of the bull (Dhuyvetter et al. 1996, 407). Previous studies using hedonic pricing models have analyzed the value of a commodity input's characteristics. In this study we also used a hedonic pricing method to look at the values associated to each purebred beef breeding bull characteristic.

The general objective of this thesis is to determine the effect information provided to buyers of purebred beef breeding bulls in an auction has on the price paid for bulls. This study adds a number of variables that the previous studies had not included. Variables added are carcass information, including adjusted carcass measurements using ultrasound, carcass expected progeny differences (EPD's), and scrotal circumference. In addition, this study is unique because volume discounts are offered to buyers of bulls and the identities of the buyers of each bull are known. This allowed us to examine if buyer experience and volume discounts affect prices paid for purebred beef breeding bulls.

The specific objectives of this study were to: 1) Determine the effects of both physical carcass measurements and carcass expected progeny differences on the price paid for breeding bulls, 2) Determine the effect that scrotal circumference has on purebred beef breeding bull prices, and 3) Determine the effect of a price discount given to volume buyers on the price paid for purebred beef breeding bulls.

This study concludes that 1) price paid for purebred beef breeding bulls is significantly related carcass measurements and carcass expected progeny differences, 2) the price paid for purebred beef breeding bulls is positively and significantly related to scrotal circumference, and 3) the price paid for purebred beef breeding bulls is positively and significantly related to a price discount given to volume buyers.

Differences in price paid for purebred beef breeding bulls are explained by the attributes or characteristics of the purebred beef breeding bulls as well as marketing variables. The results of this study are consistent with prior work and the hypotheses.

Our general objective to determine the effect of information provided to buyers of purebred beef breeding bulls, in an auction, has on the price paid for bulls. Price paid for purebred beef breeding bulls is related to purebred beef breeding bull characteristics and marketing characteristics.

Purebred beef breeding bull characteristics are related to both physical carcass measurements and carcass EPDs as well as. With the exception of the fat EPD, all carcass characteristic of the have a positive impact on the price paid for breeding bulls. Buyers of purebred beef breeding bulls are aware and their bids respond to carcass measurements and EPDs. If producers of purebred beef breeding bulls aspire to increase the price paid for their product, focusing on improvement of carcass characteristics will lead to higher prices paid for their bulls.

This study also determined that the price paid for purebred beef breeding bulls is positively related to scrotal circumference. Within normal anatomical limits, the larger the scrotal circumference the higher the price paid for the purebred beef breeding bulls.

It was also determined that offering a volume discount, as indicated by the premium paid by buyers who purchased ten or more bulls at each auction, had a positive effect on the price paid for purebred breeding bulls. However, buyer experience led to a discount in the price paid by those buyers that had purchased purebred beef breeding bulls in a previous auction.

Implications

Implications of this study are far reaching. Purebred beef breeding bull producers are only at the beginning of a long process in the production of beef. Purebred beef breeding bull producers often make decisions today that will effect them 2½ years later.

Understanding the characteristics the buyers of their bulls desire will aid them in making good timely decisions that will lead to increased profits.

Carcass measurements, both ultrasonographic measures and EPD measurements, aid producers of beef in the process of providing quality beef products for consumption. Focusing on these quality characteristics not only aids the purebred beef bull producer to increase profits, but it also assists the beef producer in increasing his profits by improving the quality of beef product sold.

Reproductive efficiency, as well as maturity is positively linked to scrotal circumference measurements. Knowing that buyers of purebred beef breeding bulls desire bulls that are reproductively efficient and early maturing, sellers of purebred beef breeding bulls can use the scrotal circumference measurement to select for those types of bulls. This will positively affect the price received for a producer's purebred beef breeding bulls.

Adding a volume discount is one marketing technique that those holding or selling bulls in an English type auction can use to increase the price paid for their bulls. There may be an undetermined additional positive influence on the price paid for purebred beef breeding bulls that increased bidding competition has on the entire population of bulls.

Suggestions

Carcass EPD's are relatively new measurement of a bulls ability to produce good quality consumable beef. Due to the newness of these measures continued study is recommended. In the past year, the American Angus Association has added new EPDs to measure carcass-grading qualities. These new EPDs are Feedlot Value ($F), Grid Value

($G), and Beef Value ($B). Due to the lack of sufficient data on these new EPDs we are unable to use them in this study.

Additionally, this study did not look at the effect that other marketing factors may have on the price paid for purebred beef breeding bulls, such as delivery discounts or insurance subsidies. Measuring this effect will be a good step in further analyzing auction theory. An extension of the volume discount study would be to determine the effect that the volume discount has on the entire population of bulls in the auction. In order to do this type of study one would need to obtain information on the runner-up bidder (the bid immediately proceeding the winning bid). At times the runner-up bidder will be a volume buyer and can push that bid beyond its predicted market price.

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APPENDIX 1

```
PROC IMPORT OUT= WORK.angus
        DATAFILE= "E:\Master's Thesis\ANGUS Final Data Set.xls"
        DBMS=EXCEL2000 REPLACE;
    GETNAMES=YES;
RUN;

proc means data= angus;
run;

data angus1;
set angus;
n= n(sale_order, auction_2, auction_3, auction_4, auction_5, age_in_days, Picture,
Recommended_for_Heifers, Shows, retention, adj__yrlig_sc, act__bw, Adj__ww,
adj__yw, adj_imf, adj__rea, birth__epd_, weaning__epd_, milk__epd_, yearling__epd_,
_imf__epd_, rea__epd_, fat__epd_, _rp__epd_, _of_auctions_Purchased_bull,
bulls_purchased__auction_specifi);
run;

data angus2;
set angus1;
if n>= 34 then delete;
run;

proc corr data= angus;
var sale_order auction_2 auction_3 auction_4 auction_5 age_in_days Picture
Recommended_for_Heifers Shows retention adj__yrlig_sc act__bw Adj__ww adj__yw
adj_imf adj__rea birth__epd_ weaning__epd_ milk__epd_ yearling__epd_ _imf__epd_
rea__epd_ fat__epd_ _rp__epd_ _of_auctions_Purchased_bull
bulls_purchased__auction_specifi;
run;

proc reg data= angus;
model winning_bid= sale_order auction_2 auction_3 auction_4 auction_5 age_in_days
Picture Recommended_for_Heifers Shows retention adj__yrlig_sc act__bw Adj__ww
adj__yw adj_imf adj__rea birth__epd_ weaning__epd_ milk__epd_ yearling__epd_
_imf__epd_ rea__epd_ fat__epd_ _rp__epd_ _of_auctions_Purchased_bull
bulls_purchased__auction_specifi bull_purchased____10
customer_purchased___10_bulls;
```

```
OUTPUT OUT=NEWANGUS p=wbhat r=ehat;
auction: test auction_2=auction_3=auction_4=auction_5;
epd: test
birth__epd_=weaning__epd_=milk__epd_=yearling__epd_=_imf__epd_=rea__epd_=fat
__epd_=_rp__epd_;
actadj: test adj__yrlig_sc=act__bw=Adj__ww=adj__yw=adj_imf=adj__rea;
run;

Proc robustreg;
class auction_2 auction_3 auction_4 auction_5 Picture Recommended_for_Heifers shows
retention bull_purchased____10 customer_purchased___10_bulls;
model winning_bid= sale_order auction_2 auction_3 auction_4 auction_5 age_in_days
Picture Recommended_for_Heifers Shows retention adj__yrlig_sc act__bw Adj__ww
adj__yw adj_imf adj__rea birth__epd_ weaning__epd_ milk__epd_ yearling__epd_
_imf__epd_ rea__epd_ fat__epd_ _rp__epd _of_auctions_Purchased_bull
bulls_purchased__auction_specifi bull_purchased____10
customer_purchased___10_bulls;
auction: test auction_2 auction_3 auction_4 auction_5;
epd: test birth__epd_ weaning__epd_ milk__epd_ yearling__epd_ _imf__epd_
rea__epd_ fat__epd_ _rp__epd_;
actadj: test adj__yrlig_sc act__bw Adj__ww adj__yw adj_imf adj__rea;

DATA NEWANGUS2; SET NEWANGUS;
sale_order2=sale_order*sale_order;
age_in_days2=age_in_days*age_in_days;
adj__yrlig_sc2=adj__yrlig_sc*adj__yrlig_sc;
act__bw2=act__bw*act__bw;
Adj__ww2=Adj__ww*Adj__ww;
adj__yw2=adj__yw*adj__yw;
adj_imf2=adj_imf*adj_imf;
adj__rea2=adj__rea*adj__rea;
birth__epd_2=birth__epd_*birth__epd_;
weaning__epd_2=weaning__epd_*weaning__epd_;
milk__epd_2=milk__epd_*milk__epd_;
yearling__epd_2=yearling__epd_*yearling__epd_;
_imf__epd_2=_imf__epd_*_imf__epd_;
rea__epd_2=rea__epd_*rea__epd_;
fat__epd_2=fat__epd_*fat__epd_;
_rp__epd_2=_rp__epd_*_rp__epd_;
_of_auctions_Purchased_bull2=_of_auctions_Purchased_bull*_of_auctions_Purchased_
bull;
bulls_purchased__auction_specif2=bulls_purchased__auction_specifi*bulls_purchased__
auction_specifi;

proc reg data= newangus2;
```

```
model Winning_bid=sale_order auction_2 auction_3 auction_4 auction_5 age_in_days
Picture Recommended_for_Heifers Shows retention adj__yrlig_sc act__bw Adj__ww
adj__yw adj_imf adj__rea birth__epd_ weaning__epd_ milk__epd_ yearling__epd_
_imf__epd_ rea__epd_ fat__epd_ _rp__epd_ _of_auctions_Purchased_bull
bulls_purchased__auction_specifi bull_purchased____10
customer_purchased___10_bulls sale_order2 age_in_days2 adj__yrlig_sc2 act__bw2
Adj__ww2 adj__yw2 adj_imf2 adj__rea2 birth__epd_2 weaning__epd_2 milk__epd_2
yearling__epd_2 _imf__epd_2 rea__epd_2 fat__epd_2 _rp__epd_2
_of_auctions_Purchased_bull2 bulls_purchased__auction_specif2;
OUTPUT OUT=NEWANGUS3 p=wbhata r=ewba;
run;

proc robustreg data=newangus3;
class auction_2 auction_3 auction_4 auction_5 Picture Recommended_for_Heifers shows
retention bull_purchased____10 customer_purchased___10_bulls;
model Winning_bid=sale_order auction_2 auction_3 auction_4 auction_5 age_in_days
Picture Recommended_for_Heifers
Shows retention adj__yrlig_sc act__bw Adj__ww adj__yw adj_imf adj__rea birth__epd_
weaning__epd_ milk__epd_ yearling__epd_ _imf__epd_ rea__epd_ fat__epd_
_rp__epd_ _of_auctions_Purchased_bull bulls_purchased__auction_specifi
bull_purchased____10 customer_purchased___10_bulls sale_order2 age_in_days2
adj__yrlig_sc2 act__bw2 Adj__ww2 adj__yw2 adj_imf2 adj__rea2 birth__epd_2
weaning__epd_2 milk__epd_2 yearling__epd_2 _imf__epd_2 rea__epd_2 fat__epd_2
_rp__epd_2 _of_auctions_Purchased_bull2 bulls_purchased__auction_specif2;
auction: test auction_2 auction_3 auction_4 auction_5;
epd: test birth__epd_ weaning__epd_ milk__epd_ yearling__epd_ _imf__epd_
rea__epd_ fat__epd_ _rp__epd_ birth__epd_2 weaning__epd_2 milk__epd_2
yearling__epd_2 _imf__epd_2 rea__epd_2 fat__epd_2 _rp__epd_2;
actadj: test adj__yrlig_sc act__bw Adj__ww adj__yw adj_imf adj__rea adj__yrlig_sc2
act__bw2 Adj__ww2 adj__yw2 adj_imf2 adj__rea2;

DATA NEWANGUS4; SET NEWANGUS3;
lwiningbid=log(winning_bid);

proc reg data= newangus4;
model lwiningbid= sale_order auction_2 auction_3 auction_4 auction_5 age_in_days
Picture Recommended_for_Heifers Shows retention adj__yrlig_sc act__bw Adj__ww
adj__yw adj_imf adj__rea birth__epd_ weaning__epd_ milk__epd_ yearling__epd_
_imf__epd_ rea__epd_ fat__epd_ _rp__epd_ _of_auctions_Purchased_bull
bulls_purchased__auction_specifi bull_purchased____10
customer_purchased___10_bulls;
output out=newangus5 p=lwbhat r=lewblin
run;
```

```
proc robustreg data=newangus4;
class auction_2 auction_3 auction_4 auction_5 Picture Recommended_for_Heifers shows
retention bull_purchased____10 customer_purchased___10_bulls;
model lwiningbid= sale_order auction_2 auction_3 auction_4 auction_5 age_in_days
Picture Recommended_for_Heifers Shows retention adj__yrlig_sc act__bw Adj__ww
adj__yw adj_imf adj__rea birth__epd_ weaning__epd_ milk__epd_ yearling__epd_
_imf__epd_ rea__epd_ fat__epd_ _rp__epd_ _of_auctions_Purchased_bull
bulls_purchased__auction_specifi bull_purchased____10
customer_purchased___10_bulls;
auction: test auction_2 auction_3 auction_4 auction_5;
epd: test birth__epd_ weaning__epd_ milk__epd_ yearling__epd_ _imf__epd_
rea__epd_ fat__epd_ _rp__epd_;
actadj: test adj__yrlig_sc act__bw Adj__ww adj__yw adj_imf adj__rea;

proc univariate normal;
var lewblin;
run;

proc reg data= newangus4;
model lwiningbid=sale_order auction_2 auction_3 auction_4 auction_5 age_in_days
Picture Recommended_for_Heifers Shows retention adj__yrlig_sc act__bw Adj__ww
adj__yw adj_imf adj__rea birth__epd_ weaning__epd_ milk__epd_ yearling__epd_
_imf__epd_ rea__epd_ fat__epd_ _rp__epd_ _of_auctions_Purchased_bull
bulls_purchased__auction_specifi bull_purchased____10
customer_purchased___10_bulls
sale_order2 age_in_days2 adj__yrlig_sc2 act__bw2 Adj__ww2 adj__yw2 adj_imf2
adj__rea2 birth__epd_2 weaning__epd_2 milk__epd_2 yearling__epd_2 _imf__epd_2
rea__epd_2 fat__epd_2 _rp__epd_2 _of_auctions_Purchased_bull2
bulls_purchased__auction_specif2;
auction: test auction_2=auction_3=auction_4=auction_5;
epd: test
birth__epd_=weaning__epd_=milk__epd_=yearling__epd_=_imf__epd_=rea__epd_=fat
__epd_=_rp__epd_=birth__epd_2=weaning__epd_2=milk__epd_2=yearling__epd_2=_i
mf__epd_2=rea__epd_2=fat__epd_2=_rp__epd_2;
actadj: test
adj__yrlig_sc=act__bw=Adj__ww=adj__yw=adj_imf=adj__rea=adj__yrlig_sc2=act__b
w2=Adj__ww2=adj__yw2=adj_imf2=adj__rea2;
output out=newangus7 p=nwbhat r=newb;
run;

proc robustreg data= newangus7;
class auction_2 auction_3 auction_4 auction_5 Picture Recommended_for_Heifers shows
retention bull_purchased____10 customer_purchased___10_bulls;
model lwiningbid=sale_order auction_2 auction_3 auction_4 auction_5 age_in_days
Picture Recommended_for_Heifers Shows retention adj__yrlig_sc act__bw Adj__ww
adj__yw adj_imf adj__rea birth__epd_weaning__epd_ milk__epd_ yearling__epd_
```

```
_imf__epd_ rea__epd_ fat__epd_ _rp__epd_ _of_auctions_Purchased_bull
bulls_purchased__auction_specifi bull_purchased____10
customer_purchased___10_bulls sale_order2 age_in_days2 adj__yrlig_sc2 act__bw2
Adj__ww2 adj__yw2 adj_imf2 adj__rea2 birth__epd_2 weaning__epd_2 milk__epd_2
yearling__epd_2 _imf__epd_2 rea__epd_2 fat__epd_2 _rp__epd_2
_of_auctions_Purchased_bull2 bulls_purchased__auction_specif2;
auction: test auction_2 auction_3 auction_4 auction_5;
epd: test birth__epd_ weaning__epd_ milk__epd_ yearling__epd_ _imf__epd_
rea__epd_ fat__epd_ _rp__epd_
birth__epd_2 weaning__epd_2 milk__epd_2 yearling__epd_2 _imf__epd_2 rea__epd_2
fat__epd_2 _rp__epd_2;
actadj: test adj__yrlig_sc act__bw Adj__ww adj__yw adj_imf adj__rea adj__yrlig_sc2
act__bw2
Adj__ww2 adj__yw2 adj_imf2 adj__rea2;
run;
proc univariate normal;
var ewba newb ehat;
run;
```

APPENDIX 2

Appendix Table 1. Correlation Matrix

	Actual Birth Weight	Adjusted Weaning Weight	Adjusted Yearling Weight	Adjusted Intramuscular Fat	Adjusted Rib Eye Area	Birth Weight EPD	Weaning Weight EPD	Milk EPD	Yearling Weight EPD	Intramuscular Fat EPD	Rib Eye Area EDP	Fat Thickness EPD	Retail Product EPD
Act BW	1.00000	0.09576	0.13634	-0.02275	0.09135	0.45280	0.10407	0.01552	0.05123	0.08407	0.01473	-0.07034	-0.01864
Adj WW	0.09576	1.00000	0.66823	0.09529	0.30661	0.02296	0.31385	0.16166	0.23005	-0.04931	0.04405	0.01706	-0.11549
Adj YW	0.13634	0.66823	1.00000	0.11440	0.44025	0.01971	0.30065	0.18099	0.33849	0.14540	0.17090	0.09094	-0.19419
Adj IMF	-0.02275	0.09529	0.11440	1.00000	0.27400	-0.15263	-0.04976	0.17089	0.54590	0.61600	0.58840	0.28529	-0.09612
Adj REA	0.09135	0.30661	0.44025	0.02740	1.00000	-0.09602	0.04886	0.10597	0.05735	0.03236	0.59076	-0.02247	0.36978
BW EPD	0.45280	0.02296	0.01971	-0.15263	-0.09602	1.00000	0.31144	-0.23542	0.20932	-0.23926	-0.03652	-0.07054	-0.09240
WW EPD	0.10407	0.31385	0.30065	-0.04796	0.04886	0.31144	1.00000	0.09900	0.83883	0.01262	0.13616	0.11105	-0.20778
Milk EPD	0.01552	0.16166	0.18099	0.17089	0.10597	-0.23542	0.09900	1.00000	0.15378	0.28831	0.16914	0.14868	0.02367
YW EPD	0.05123	0.23005	0.33849	0.05459	0.05735	0.20932	0.83883	0.15378	1.00000	0.20450	0.19792	0.20237	-0.25294
IMF EPD	-0.08407	-0.04931	0.01454	0.61600	0.32360	-0.23926	0.01262	0.28831	0.20450	1.00000	0.31975	0.48202	-0.02113
REA EPD	0.01473	0.04405	0.17090	0.05884	0.59076	-0.03652	0.13616	0.16914	0.19792	0.31975	1.00000	0.12001	0.56989
Fat EPD	-0.07034	0.01706	0.90940	0.28529	-0.02247	-0.07054	0.11105	0.14868	0.20237	0.48202	0.12001	1.00000	-0.55818
RP EPD	-0.01864	-0.11549	-0.19419	-0.09612	0.36978	-0.09240	-0.20778	0.02367	-0.25294	-0.02113	0.56989	-0.55818	1.00000

VITA

Phillip Ray Humphrey

Candidate for the Degree of

Master of Science

Thesis: HEDONIC ANALYSIS OF PUREBRED BEEF BULL PRICES

Major Field: Agricultural Economics

Biographical:

Personal Data: Born in Logan, Utah on January 28th, 1975, the son of Kimball and Wendy Humphrey. Married to Stephanie LaNae Holyoak Humphrey on August 4th 2000. Father to Cooper Davis Humphrey, born January 24th, 2002, and Greyson Reed Humphrey, born June 9th, 2004.

Education: Graduated from Noble High School, Noble, Oklahoma in May 1993; received Bachelor of Science degree in Agricultural Economics with a minor in International Business from Oklahoma State University in May 2000. Completed the requirements for Master of Science degree with a major in Agricultural Economics at Oklahoma State University in December 2004.

Experience: Raised on a small farm in Noble, Oklahoma where my family was involve in a purebred cattle operation; employed a ranch manager for Roll Top Inc. from 1990-1994 and 1996-2000; active as a full time volunteer in Sacramento, CA, aiding Hmong political refugees from 1994-1996; employed as a student employee at Oklahoma State University, Department of Agricultural Economics from 1998-2000; employed by Cargill Inc., Animal Nutrition Division, in the Administrative Manager Trainee program from 2000-2001, and then as a District Merchant from 2001-2002; employed as a graduate teaching and research assistant at Oklahoma State University, Department of Agricultural Economics from 2002-2004.

Name: Phillip R. Humphrey Date of Degree: December, 2004

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: HEDONIC ANALYSIS OF PUREBRED BEEF BULL PRICES

Pages in Study: 56 Candidate for the Degree of Master of Science

Major Field: Agricultural Economics

Scope and Method of Study: Purebred beef breeding bulls are a key input in the production process for beef cattle. This study estimates the value that each characteristic contributes to the price paid for a purebred beef breeding bull. The important EPD characteristics included in this study are birth-weight, weaning-weight, milk, yearling-weight, rib eye area, percent intramuscular fat, fat, and percent retail product.

Findings and Conclusions: The disparity in price paid for purebred beef breeding bulls can be explained by a breakdown of characteristics and their associated values. This study determined that both physical carcass measurements and carcass EPDs with the exception of the fat EPD have a positive relationship on the price paid for purebred beef breeding bulls. Buyers of purebred beef breeding bulls are aware and price responsive to carcass measurements and EPDs. Additionally the price paid for purebred beef breeding bulls is positively related to scrotal circumference and volume discount.

ADVISORS APPROVAL: Daniel S. Tilley