THE ECONOMIC VALUE OF CARCASS TRAITS,

AND THEIR DIFFERENCES ACROSS BULL SALES

by

Joseph Keith Vanek

A thesis submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Applied Economics

MONTANA STATE UNIVERSITY
Bozeman, Montana

November 2007

APPROVAL

of a thesis submitted by

Joseph Keith Vanek

This thesis has been read by each member of the master's committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the Division of Graduate Education.

Dr. Myles Watts

Approved for the Department of Agricultural Economics and Economics

Dr. Myles Watts

Approved for the Division of Graduate Education

Dr. Carl A. Fox

STATEMENT OF PERMISSION TO USE

Joseph Keith Vanek

November 2007

ACKNOWLEDGMENTS

I would like to extend a thank you to my thesis committee. Dr. Myles Watts, thesis chair, provided unlimited support, patience, and encouragement through the process. I would like to thank Dr. Gary Brester and Dr. Chris Stoddard for providing comments and assistance.

I would like to extend a thank you to the bull producers who supplied data for this research. Their comments and cooperation were very beneficial.

I would thank the faculty and staff of the Ag Econ and Econ department for their support and comments towards the completion of this research. I would especially like to thank Dr. John Marsh and Dr. Wendy Stock for econometric assistance. I also would like to thank Dr. Joe Atwood for his assistance with data management.

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ABSTRACT

Higher quality beef can only be distinguished from lower quality beef in the final stages of production when animals are slaughter. Because of quality measurement issues it is difficult to determine and value higher quality animals at the individual levels of beef production.

Cow-calf producers are the primary supply of cattle into the beef marketing chain. The genetics introduced at this level follow through to the slaughter stage. Cow-calf producers use expected progeny differences (EPDs) provided at seed stock bull sales to make selective breeding decisions. The introduction of carcass EPDs has technologically advanced a cow-calf producer's ability to select bulls based on carcass quality traits. A cow-calf producer will increase profits by reacting to market conditions and selectively choosing breeding livestock.

By evaluating the prices paid for seed stock bulls at auction sales, this thesis will attempt to determine the value of animals with high carcass merit. If cow-calf producers are reacting to the increased demand for high quality beef they should make selective breeding decisions based expected carcass performance.

A hedonic pricing was used to determine the implicit value of traits embedding in bull prices. The regression model was formulated to correct for the multicollinearity of traits. Regression results indicate that cow-calf producers do value the ability to predict carcass quality of a bull's progeny. This is an indication that information pertaining to carcass quality is being transmitted through the beef marketing chain. The direct channel of flow, however, has not been determined

CHAPTER 1

INTRODUCTION

The prime rib is one of the most desired cuts of beef by consumers. Prime rib is taken from the loin of the animal and is measured by rib-eye-area. . Consumers indulge in the tender, juicy, rich flavor of prime rib. Setting seasonings and cooking techniques aside, the tenderness, flavor and moistness of the prime rib is determined by the amount of intramuscular fat. Intramuscular fat is the amount of fat within the muscle. Because prime rib doesn't solely determine the beef demand, the same principals apply to all cuts of beef.

The demand for beef is driven by the quantity of desirable high end retail cuts, and the flavor and tenderness (quality) of the meat. The consumer wants every steak to taste the same, and wants a lot of steak. This places pressure on the beef industry to produce a consistent high quality product. The beef market must then differentiate between high and low quality beef at the individual levels of production. The primary demand for beef starts with consumer, and the derived demand will extend from the packer through the feedlot level to the cow-calf producer at the farm level.

As changes in the beef market occur at the primary level and filter down to the derived levels, theory indicates each level will act accordingly. As consumers demand a higher quality and consistent beef product, it likely follows that information pertaining to carcass quality will reach the cow-calf producer; assuming high and low quality products can be differentiated.

But how does the cow-calf producer value increased quality when it can only be observed at the final stages of production and is subjective to the cooking practices and tastes of a consumer? For the cow-calf producer the primary demand for the high quality product has long been detached, since the sale of feeder calves takes place roughly 18 to 24 months prior to the product reaching the consumer's plate. There is no direct measurement of quality in the beef marketing chain between the consumer and a cow-calf producer. However, a cow-calf producer reacts to the market by purchasing seed stock bulls and selecting bulls based on genetic carcass improvement capabilities

This thesis will measure the value of increased carcass quality from the perspective of a cow-calf producer. Cow-calf producers will react to market changes and information to reduce the risk of producing low quality animals. The reduction in risk is achieved by selective breeding, potentially increasing profits.

Beef Marketing Levels

Before the steak makes it to the consumer's plate it must first be processed from a live animal. Packers perform these duties and in theory are rewarded for a higher quality product and receive discounts for lower quality product from the retail level. But, packers have no easy means of distinguishing a high quality animal from a low quality animal prior to processing, *ceteris paribus*. The quality of the incoming product is determined at two major stages of the beef market before the packer level, the feedlot and the farm.

The feedlot's initial input is feeder calves from the farm level, and the output is then finished cattle to the packer. The type of feed as well as genetics plays an important role in determining the final consistency and quality of the beef product. Feeding two animals the same, one will be high quality and one will be low quality. The animals will then be valued based on the expected carcass quality. Feedlot operators may use farmer reputation or breed characteristics to predict carcass quality. But they have no exact measure of the carcass quality of the cattle received from the farm.

The farm level is where the quality of the animal begins. At this level the farmer, cow-calf producer, selects the genetics of the cattle and these genetics affect the quality of the beef at the retail level. Again, at the farm level there is also no direct measure of carcass quality. However, the cow-calf producer is supplied with genetic carcass information such as intramuscular fat and rib-eye-area expected progeny differences (EPDs). Cow-calf producers use carcass EPDs as well as other EPDs to make breeding selections as they react to changing market conditions.

Risk Management and EPDs

Cow-calf producers choose marketing strategies, production strategies, and risk management options to increase their operations' profitability. Producers participate in future and option trades which assist in reducing price risk. Cattle producers also reduce risk by selective breeding. Selective breeding is how the producer selects the genotypic and phenotypic attributes of the herd to increase productivity. Producer and economists believe selective breeding will be enacted to maximize profits (Kerr, 1984). Walburger

(2002) believes a producer can increase profits by selecting for carcass quality because, "the perception that the beef product quality is inconsistent and has resulted in losses of market share to poultry and pork products." To increase the consistency of the beef product, selection must be made on carcass quality traits such as rib-eye-are and intramuscular fat. These traits do not have an observable characteristic on the live animal and must be selected based on genetic predictions. Among the tools producers can use to make selections based on genetics are expected progeny differences or EPDs. EPDs are a prediction of the performance of future progeny.

According to Chvosta (2001) EPDs have been widely accepted by most breed associations, and were first used in about 1988. They were distributed by purebred breeders to provide information at production sales. Before EPDs purebred bulls were evaluated on physical or observable traits, such as the bull's own weight. EPDs as a selection tool provide insight into the genetics of the animal and predict progeny performance.[1] EPDs were initially used as a selection tool in decision making for weight gain potential and maternal traits. With the development of carcass quality EPDs, intramuscular fat and rib-eye-area, over the pas four to five year, these EPDs have become a widespread tool used in the evaluation of carcass performance.

Objectives

Studies by Dhyvetter (1996), Chvosta (2001), Walburger (2002), and Turner (2004) have focused on weight gain and/or maternal trait EPDs. These studies have

[1] For further discussion on the information provided by EPDs and the reduction in transaction cost to buyers refer to Chvosta, Rucker, and Watts, 2001.

compared actual (own performance) traits to the EPDs (predicted performance) and attempted to estimate whether EPDs provide the kind of information valued by bull buyers. The analysis presented here will use similar hedonic models to estimate the value of carcass EPDs to cow-calf producers purchasing purebred Angus Bulls and cross-bred bulls.

This thesis has the following objectives. First, it will confirm the findings of previous research relating to the value of EPDs. However, this thesis builds on past work by formulating the regression model to avoid collinearity of some traits. The second objective is to estimate the value of carcass quality EPDs. The spatial aspects of implicit EPD values will also be evaluated across the different purebred breeders. Changes in the implicit values over time will also be investigated. This thesis will evaluate differences in the marginal value of EPDs between purebred and cross-bred bull buyers.

Thesis Outline

This thesis is broken into nine chapters. EPDs are explained in chapter two. Chapter three discusses the grounding economic theory. Previous research and the development of hedonic models are discussed in chapter four. The econometric analysis is presented in chapter five. A further discussion of the data obtained is in chapter six. Chapters seven and eight provide a discussion of the regression results. The contribution to the cattle industry will be in the final conclusion, chapter nine.

CHAPTER 2

EXPECTED PROGENY DIFFERENCE

Description of EPDs

The American Angus Association describes Expected Progeny Difference (EPD) as “the prediction of how future progeny of each animal are expected to perform relative to the progeny of other animals.” Expected progeny differences (EPDs) are calculated using statistical models that incorporate information from an ancestral line such as grandparents, parents, siblings, progeny, own performance information, and other information specific to location and conditions. EPDs are then expressed in units of the trait either above or below a given breed average.

For example, birth-weight is measured in pounds, therefore the birth-weight EPD is measured in pounds. If the birth-weight EPD for Bull A is +5, then calves sired by Bull A would be expected on average to be 5 pounds heavier than the given breed average. If the breed average is 75 pounds, the expected average birth-weight of Bull A’s calves is 80 pounds.

The EPD predicts the average difference over a large number of progeny. EPDs in essence provide a quick reference and easy comparison of cattle within herds and between individual purebred breeders. EPDs available to producers can only be used to make direct comparisons of animals of the same breed (Beef Sire Selection Manual, 2007).

The average animal's EPD is usually set at zero for a specific base year. Different breed associations may choose different base years for calculating EPDs or may calculate the EPDs in a slightly different manner. The American Angus Association recalculates a base year every two to five years. Other breed associations may calculate the base year more or less frequently, and so the base year and the change between base years may vary across breeds. For, example the Continental breeds tend to grow faster than the British breeds. So comparing the growth related EPDs from an Angus to a Charolais would be inappropriate. In the most basic comparison they grow differently. Across-breed adjustment factors to within-breed EPDs are published in the Beef Sire Selection Manual and are updated annually to facilitate across-breed comparisons. After making the adjustment the comparison could be made between Charolais and Angus cattle.

EPDs have been accepted as a viable source of information; however, caution should be used, as they are only estimates. As with most traits, there is always the possibility of acquiring recessive genes. Thus, a bull with a highly desirable EPD value, an estimate of performance, could be the carrier for a non-desirable trait, resulting in lower actual performance. A bull with a low and desirable birth-weight EPD could actually produce calves with high undesirable birth-weights.

EPDs are statistically estimated values of the true genetic merit or breeding values. EPD accuracy increases as the sire has more progeny and adds data used to estimate the EPD. Young bulls, have a lower accuracy level than older bulls since older bulls have more progeny. In theory, accuracy can range from 0 (no information) to 1 (exact true genetic value known). In reality, accuracies for traits, such as growth, are typically reported in sire summaries in the 0.40 to 0.99 range, and each individual trait has its own acceptable reporting accuracy determined by the breed association.

The American Angus Association, the largest breed association, provides EPDs in four categories: production, maternal, carcass, and value indexes.[2] Production EPDs include birth weights, weaning weights (205 days) and yearling weights (365 days). The maternal EPDs are designed to compare the maternal traits (e.g. milking ability) a bull will pass on to female offspring. Carcass EPDs (e.g. rib-eye-area) are used to compare the genetic and physical carcass traits of different sires.

All EPDs are calculated by using genetic and physical information. In most instances there is an actual physical trait that can be measured. Information from the animal itself and information from relatives are used in calculations. For example, the actual birth-weight of a bull and the birth-weights of relatives are used to calculate the birth-weight EPD.

Carcass EPDs are calculated similarly, however, the actual physical measurement can only be taken when the animal is slaughtered. An ultrasound measurement is then substituted for the own actual animal measurement. With carcass quality, some of the information will be taken from slaughtered relatives.

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[2] For a complete description of all the EPDs used by the American Angus Association please refer to their Web site, www.angus.org. Refer to other breed specific Web sites, for breed EPDs other than American Angus.

Development of EPDs

The predecessor to EPDs was the multi-trait best linear unbiased predictor (BLUP) model of Henderson (1949). Prior models only predicted single traits for a close group of relatives. Henderson (1976) recognized advantages to inverting the matrix of relationships, thus, making it simpler to simultaneously incorporate all relatives into the equation rather than just close relatives. Henderson and Quaas (1976) included correlated traits into the model. This then created a multi-trait prediction.

Quaas and Pollack (1980, 1981 a, b) extended the multi-trait prediction model to adjust for missing information. Because these calculations were computed on young animals, it was possible that not all the information was available. For example, an estimate may be made after the animal was weaned but before the animal was a year old. Thus, the own yearling weight would be missing, however, a yearling weight prediction could be calculated.

Prior models only included information pertaining to the sires and their progeny performance. The models by Quass and Pollack (1980, 1981 a, b) were extended to account for the dam’s progeny performance and the performance of young animals with no progeny. They estimated the traits simultaneously accounting for across-trait correlations and controlled for variables such as environmental differences and genetic trend. The development of genetic prediction was originally applied to the genetic evaluation of dairy animals (Quaas and Pollack, 1980). The model has since been expanded into beef cattle genetic evaluation and adopted by beef cattle associations.

The models described above are the basis for the models used by the separate breed associations today. The models currently used predict multiple traits simultaneously and are expected to be true predictors of genetic merit. Even though the models today are much more complex than originally designed they are the estimators accepted by cow-calf producers for the genetic selection of cattle.

CHAPTER 3

ECONOMIC THEORY

EPDs are useful predicting tools for determining the future performance of progeny of seed-stock bulls. Buyers of bulls use this information for selective breeding purposes. The further development of carcass quality EPDs has advanced the technology for selecting breeding cattle, increasing the ability of cow-calf producers to select the best bulls for their operation. A cow-calf producer then reduces the risk of poor progeny performance and increases potential profits. The higher profits generate economic value for the EPDs. Carcass quality is not readily observable on breeding livestock. Previous to EPDs, the search cost for information on a bull's expected carcass quality was high. Carcass quality data on harvested relatives was not readily available, and gathering the data was expensive. Furthermore, carcass information developed by one buyer might not have been available to other buyers resulting in duplicate efforts. The development of EPDs reduced carcass information costs and increased the available information on carcass quality to buyers of seed-stock bulls.

Description of Cow-Calf Producers

For simplification, cow-calf producers are assumed to maximize profits. This assumption is important in the analysis to maintain that bulls are purchased based on traits that improve the quality of calves and increase operations' profitability. The underlying profit or cost functions for cow-calf producers are heterogeneous. Cow-calf producers have individual breeding practices. Many commercial herds are based on the maximization of heterosis.[3] This is accomplished through cross breeding. Holding all else constant, two cow-calf producers will value bull traits differently because of the type of cross they are performing. Therefore, not all cow-calf producers value the quantity of traits identically, creating heterogeneous distribution of values. This also assumes the cow-calf producer is sophisticated in selection procedures.

Selective Breeding

Purchasing bulls is one of the main channels and means of improving the productivity of a cow herd (Kerr, 1984).[4] Producers make decisions that increase uniformity within the herd by selecting for certain traits in bulls and mother cows so that they will then pass on desirable traits to the offspring (calves). These desirable traits directly impact the producers' profits. Additional profits attained through selective breeding are subject to the variation of traits in the producer's herd. This variation ultimately determines the amount of genetic change that can be made from within herd breeding.

A larger variation in traits across the herd allows for more potential changes, and a producer with a large variation across the herd may have a greater ability to make genetic improvements from within the herd. A producer with a smaller variation must

[3] The Beef Improvements Federation (BIF) describes heterosis as "the amount by which the average performance for a trait in crossbred calves exceeds the average performance of the two or more purebreds that were mated in that particular cross."

[4] Selective breeding is only beneficial when the proper traits are selected. It is also sensitive to the specific operation. For Example, Farm A and Farm B will have different traits of selection to develop a uniform product. What is good for Farm A may not be good for Farm B. Farm A may maximize profits by selling calves directly into a feedlot operation and Farm B maximizes profits back grounding. Environment is another factor that may differ between producers.

introduce genetics from outside the herd. This is usually done with bulls, which are the main channel through which the producers can improve or change the genetics in the herd. Bulls can either be selected from internal breeding or purchased from the outside.

The variation of traits creates a conundrum for those who may purchase and value purebred bulls. The only way for a producer with low variation to increase genetic merit is to purchase bulls, as genetic improvements from within herd cannot be made. A producer who has larger variation of traits may also purchase bulls to increase genetic merit.

The ultimate goal in either situation is to increase uniformity[5] and achieve high genetic merit. This is most clearly seen in how producers select for weight and gain traits, since calves are usually sold "by the pound." Producing calves with uniform weaning or yearling weights decrease the risk associated with receiving "slides" or "cut backs" at the time of sale.[6]

Carcass Quality Aspects

If carcass quality can be selected based on genetic indicators (EPDs), then selective breeding will lead to a higher level of quality uniformity across carcasses. The

[5] Uniformity means that on average the pen of calves will be similar in traits. Not all the calves in the pen are the same, producing outliers to the average. One purpose of selective breeding is to decrease the variation in a group of animals. The producer may also be using selective breeding to change the average of the attributes of the pen of calves. An example: Farm A wants to sell calves at 650 pounds at weaning. Bulls are selected with a higher (lower) expected gain EPD to produce a pen of calves with an average of 650 pounds.

[6] Cattle are generally sold in lots and the producer receives a discount if the pen is lighter (heavier) than the average weight for the agreed price. If a pen of calves is sold at 650 pound average at weaning, and the average is excessively light (600 lbs) or heavy (700 lbs) the pen will be discounted. This discount is called the slide. Cut backs are individual animals that are substantially lighter (heavier) than the rest of the calves in the group. Cut backs are separated from the group and sold at a reduced price.

increased quality uniformity of carcasses will truncate the lower grading carcasses and increase the number of carcasses that grade select and choice. Processors react to the tastes and preferences of the primary consumer demand. Consumer demand is affected by the quality of beef, intramuscular fat and rib-eye-area. Based on theory, as processors react to the consumer demand, these changes in primary demand will affect the derived demand at the feeder and cow-calf levels. Feeders also desire uniformity so that animals will finish at about the same time, reducing marketing and production costs. A cow-calf producer, facing a derived demand for the product, will select cattle with EPDs that in turn increase the uniformity of the product at the beginning stages of production.[7] Therefore, changes in the beef industry can be seen through the actions of cow-calf producers as they select bulls.

More desirable carcass traits will be valued if bulls with high-quality traits can be differentiated from other bulls with lower quality traits. Carcass EPDs developed from ultrasound, combined with actual quality assessments of slaughtered relatives, are carcass quality indicators. If buyers believe EPDs are useful indicators for selective breeding then carcass EPDs will influence a bull price.

Information Transparency

As information flows through the beef marketing chain from the retail to cow-calf level, the value of profit-increasing traits will be recognized in bull prices. The value of a bull is then represented by the marginal value of the traits a bull possesses. This is because cow-calf producers are at the beginning stages of beef production, primary

[7] For a further discussion on primary and derived demand, refer to Tomek and Robinson (1990) Chapter 6.

supply. Their breeding techniques affect the product throughout the remaining levels, derived supply. So if higher carcass merit is desired at the slaughter level, the information will be transmitted down through the ranks to the cow-calf producer.

However, if this information is not being transmitted through beef production systems to cow-calf producers, then the value of a trait could be zero. The marginal cost of obtaining and transmitting the information must be less than the benefits received or else the information will not be transmitted. For example, information pertaining to carcass quality has historically been expensive. If the cost to collect and transfer this data from one production level to another outweighs the benefits of using the data, then the information will not flow through the beef market chain. Thus, analyzing the value of carcass information at the cow-calf level could be zero, even though the information does have value at the retail level.

Summary

Cow-calf producers will participate in selective breeding practices to increase profits and reduce risk. If information is traveling through the beef marketing chain, cow-calf producer will respond to that information as it affects profits. By using carcass EPDs, buyers will reduce the risk of purchasing breeding livestock that produce low quality offspring. This acts as a technological advance in the beef industry. Demand for breeding cattle with high quality traits shifts outward and thereby increases the prices paid for high quality bulls. Therefore, the value of desirable carcass traits is recognized in the price of a bull.

CHAPTER 4

REVIEW OF LITERATURE

There has been extensive research completed on the development and use of hedonic models. These applications have extended from consumer theory to production. Previous research directly relating to the value of EPDs has used hedonic models to estimate the marginal values. This thesis builds upon previous models and makes corrections to increase the robustness of the results.

Development of Hedonic Models

Hedonic price modeling was first used to model household choice. Gary Becker (1965) and Kevin Landcaster (1966) incorporated the characteristics of products into the utility function in place of the products themselves. In their models, consumers maximize utility over the product characteristics rather than the products per se.

Rosen (1974) describes hedonic prices as "the implicit prices of attributes that are revealed to economic agents from observed prices of differentiated products that contain differing amounts of specific characteristics." Rosen (1974) econometrically estimates the hedonic prices of characteristics. His methods lay the grounding procedures used in this thesis.

Each good in the market has a vector $z = (z_1, z_2, \ldots, z_k)$ of characteristics. Goods are defined by these characteristics, and goods only differ in the amount of each characteristic possessed. The characteristics of the good are measured by the consumer, and the consumer is aware of the amount of the characteristics in each good. The consumer then makes a selection based on the level of characteristics (Rosen, 1974). The market is assumed to be in a competitive equilibrium for all goods. The choices that can be made among these products are continuous in *z*. Each product has a market price that is associated with the values of the characteristics. The market price for a product then reveals a function of characteristic prices, $p(z) = p(z_1, z_2, \ldots, z_k)$ (Rosen, 1974).

Relating back to Becker (1965) and Landcaster (1966), the consumer receives utility from the characteristics of the product, not the product it's self. The utility function can then be written as such, $U(x, z_1, z_2, \ldots, z_k)$, where it is strictly concave with additional usual properties required for an interior solution. A consumer maximizes utility by consuming *x,* all other goods, and the product of interest *n*, where z_i represents the characteristics of *n*.

Rosen (1974) extended the hedonic models into production, where firms are considered competitors and not monopolists. The same principles from consumer utility maximization apply to the competitive profit maximizing production. This indicates that the producer will chose the input characteristic level based on the input demand for that characteristic.

Rosen (1974) determined that the observed price differentials are exactly equalizing across buyers, and $p(z)$ identifies the structure of demand. The function $p(z)$ is identical with the set of hedonic prices. These hedonic prices are determined when the market clears (Rosen, 1974). Producers and consumers then meet when the producer offers the quality z_i to a consumer who demands z_i. Prices and quantities will clear in the market.[8]

(1a) $$p_i(z) = F^i(z_1,..., z_n, Y_1)$$

(1b) $$p_i(z) = G^i(z_1,..., z_n, Y_2)$$

Equations (1a) and (1b) represent the inverse supply and demand equations derived by Rosen (1974) for the implicit prices of z_i. From these two equations, the hedonic prices of the characteristic z_i can be estimated. P_i and z_i are jointly dependant variables and Y_1 and Y_2 are exogenous demand and supply shift variables.[9] $F^i(z,Y_1)$ represents the marginal demand price for z_i, and $G^i(z,Y_2)$ represents the marginal supply price.

Ladd and Martin (1976) realize that demand for an input is affected by the input's characteristics and use a neoclassical approach to evaluate the demand for input characteristics for different corn grades. Differences in yield characteristics affect the producer's decision and the value of the corn is a summation of the characteristics (Ladd and Martin, 1976).

Previous Research on the Value of EPDs

Dhuyvetter and his co-authors believed (1996) "the value of the bull is determined by its expected value in production." Following Ladd and Martin (1976),

[8] Further discussion on short-run and long-run equilibrium is addressed in Rosen (1976). Complex derivation and graphic analysis is provided.
[9] Y_1 and Y_2 represent variables such as income, substitutes and associated prices, interest rates, etc.

Dhuyvetter (1996) used a hedonic pricing model to statistically evaluate the hedonic prices of EPDs embedded in bull prices.

The model is:

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

where r_i is the price of the bull; T_j is the marginal price paid for the jth characteristic for bull *i*. The quantity of the trait possessed by bull i is x_{ji} s;

Dhuyvetter (1996) used physical and genetic traits such as age, soundness, structural, polled, breed and color. Expected performance measures were the EPDs associated with traits such as birth-weight and weaning weight. Marketing factors used by the purebred producer are also added to the model. Dhuyvetter (1996) compared two regressions: a restricted regression containing only physical trait values and an unrestricted regression that included EPDs values. This allowed him to investigate the acceptance of EPDs to producers through the estimates of the hedonic model. Since EPDs were relatively new in 1995, producers may not have been familiar with EPDs or may not have believed the information provided by EPDs was valuable.

Their findings indicate that expected performance variables (EPDs) were important in explaining price for most breeds evaluated. This indicated that EPDs from some breed associations were valued by the buyers of purebred bulls. Dhuyvetter and his team (1996) separated the breeds in the regression because of the differences in calculations of EPDs across the breeds. Results supported that at least some EPDs have value to buyers. However, results were inconclusive as to whether producers preferred

EPDs to actual trait measurements.[10] Dhuyvetter (1996) completed his research before carcass qualities EPDs were readily available.[11]

Chvosta, Rucker, and Watts (2001) analyzed the incentives of bull buyers to undertake presale measurement activities when purchasing bulls. These activities include evaluating the bull for predicted performance. Two different types of performance trait measures were appraised for their ability to reduce presale measurement costs. These measurements were simple performance measures (SPMs) and expected progeny differences (EPDs). The SPMs are measurements of the bull's own trait, i.e., own birth-weight.

Chvosta, Rucker, and Watts (2001) understood "performance measures are designed to reduce the uncertainty regarding a sale bull's future genetic performance, which will reduce the uncertainty regarding a bull's future value as a breeding animal." Performance measures are supplied by sellers at the time of sale to assist in reducing pre-sale measurement costs. Prior to 1988, sellers of purebred bulls did not provide buyers with EPD information (Chvosta, Rucker, and Watts, 2001). EPDs are expected to be more accurate indicators of progeny performance reducing uncertainty about the bull's predicted traits. The authors also realized "EPDs include information on the performance of the sale bull's relatives that is not included in the SPMs." As the uncertainty decreases, the buyer is better able to evaluate the bull's predicted performance, reducing the associated presale transaction costs.

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[10] Refer to Dhuyvetter et al. (1996) for a complete description of the model and results. Also refer to their discussion of different marketing factors.

[11] The data used by Dhuyvetter et al. (1996) contained 1,700 observations from 26 purebred bull sales in Kansas in 1993. Because of the nature of the data no intertemporal results could be obtained.

A comparison was made across different groups of buyers using a hedonic model. The analysis included data from a Montana producer as well as data provided by the American Angus Association on 11 different Angus breeders from South Dakota and Nebraska.[12] With two sets of data, the authors evaluated different groups of buyers paying different prices for bulls. EPDs were expected to contribute greater explanatory power than SPMs because EPDs potentially provide more information to buyers. They assumed that cow-calf producers valued the genetic information in EPDs, and this would lead to EPDs explaining more price variation (Chvosta, Rucker, and Watts, 2001).

However, it was still not clear how much extra information EPDs provide to bull buyers. By using a price decomposition analysis they found that EPDs were valuable at least to a small sample of buyers. Their results indicated that SPMs were more valuable when comparing animals within a herd, but EPDs were more valuable when comparing animals across herds.

The first attempt to analyze the importance of carcass related traits, i.e., rib-eye-area and intramuscular fat, was conducted in Canada. Allen Wallburger (2002) examined how cow-calf producers purchased bulls based on attributes that were expected to increase the operation's profits. Wallburger (2002) was motivated by changing trends in the industry and the perception that beef products were not as uniform as their substitutes. He evaluates whether cow-calf producers are using selective breeding techniques to in increase profits and regain market share. These trends (perceived or real) have provided

[12] The data for empirical analysis contained 1,144 observations on bulls sold in Montana between 1982 and 1997 and 6,685 observation from the American Angus Association from 1986 to 1996. They also used additional data in their analysis, however the results did not provide any additional information. For further discussion refer to Chvosta, Rucker, and Watts, 2001. OLS was the estimator.

incentive at all levels of production to develop strategies improving the quality of beef (Walburger, 2002).

Following Ladd and Martin (1976), Walburger (2002) assumed "a perfectly competitive market where cattle breeders maximize profits subject to an input characteristic production function." Walburger also used a hedonic model by regressing the bull's sale price on the bull's attributes. He then determined the implicit prices of the attributes.

Wallburger (2002) combined all the attributes of the bull to get an overall bull quality effect on profitability.[13] He then separated the impacts of the different EPDs for their marginal contributions to profitability. With only two years of carcass data, the results pertaining to carcass quality were mixed. Intramuscular fat and rib-eye-area were found to be significant in some cases and not in other.

Walburger (2002) does support the implications that cow-calf producers do make selections based on attributes that increase profitability and producers make selections for highly heritable desirable traits. The results also provide some evidence that the beef industry may be changing.

A more recent study, performed by a master's, student at Kansas State University, followed the model of Chvosta, Rucker, and Watts (2001). Turner (2004) re-evaluated the relationship between actual measurements and corresponding EPDs. The primary interest was to determine which measurement was valued more by bull buyers. The results from this research were mixed. Birth-weight EPD had a higher predicted

[13] The data for Walburger's (2002) empirical analysis contained 797 observations from 1989, 1993, 1996-2000. The data was collected from the Lakeland College Bull Test Station.

parameter than the actual birth-weight, but yearling weight EPD had a lower predicted parameter than the actual yearling weight.

Turner's (2004) data also included information on carcass quality EPDs. His results did indicate that buyers of bulls value the information provided by carcass traits. His research also provided information pertaining to the acceptance of carcass EPDs. In his study, 28 of the 60 sales reported carcass EPD information.

Summary

Previous research in this area of study has focused on the amount of information embedded in EPDs and the value of that information compared to actual physical measurements for performance SPMs. These prior economic studies have not addressed the collinearity of EPDs in the structure of the regression model, and previous results regarding the weight gain traits have been mixed, sometimes the estimated parameters do not have the expected sign. For example, the parameters associated with 365 day weight, estimated by Chvosta (2001) were statistically significant (t-value greater than 2) in both regressions used, but in one regression the estimate was positive and in the other regression it was negative.

In the majority of these studies, information pertaining to carcass quality was not readily available. The research that has been completed pertaining to the value or carcass EPDs is scarce.

Previous studies also incorporated data from separate ranches or different sale. By pooling the data only one parameter for each trait was estimated. This did not allow for any comparison across individual sales.

This thesis will correct for multicollinearity between gain traits and exclude related SPMs[14]. The research of this thesis contains two years of carcass quality information for each ranch included. Differences between groups of buyers can be evaluated as direct individual estimates for each trait specific to each ranch. There are five ranches included in the data for this thesis, each with individual parameter estimates.

[14] EPDs contain the animals own performance information., and SPMs are the measurements of the animals own performance. Therefore, by construction EPDs contain SPM information. For example the SPM for birth-weight is the actual weight of the calf at birth; the birth-weight EPD contains information from relatives and the SPM measurement, creating collinearity.

CHAPTER 5

METHODS AND PROCEDURES

Econometric Models

Three differently structured econometric models were considered to estimate the value of the traits. The first is to estimate individual ranch regressions; the second is to pool the data and use a slope dummy variable approach; and the third uses a Block Matrix approach by Zellner on the pooled data. The interpretation of results is similar across the models. These models are then standardized for further analysis. Multicollinearity is apparent between the gain traits. The correction for multicollinearity is to create three independent variables. One regression will evaluate the variable birth to yearling gain and the other regression will estimate pre- and post-weaning gain. For this reason there will be two separate regressions.

Individual Ranch Regressions

A hedonic model will be used to estimate the implicit value of a bull's traits (EPDs) from the bull's sale price. The method used to estimate the model will be Ordinary Least Squares Regression (OLS). The hedonic model used will closely follow models from Becker (1965), Landcaster (1966), Rosen (1974), Ladd and Martin (1976), and Palmquist (1989). Through this model, the implicit value of the EPDs, birth-weight, gain, and carcass quality will be estimated, allowing for interpretation of the value and importance of such traits to cow-calf producers.[15]

Following Ladd and Martin (1976), the price of the bull is a function of the traits the bull possesses.

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

In equation (3) p_i is the price of the bull; T_j is the marginal implicit price paid for the jth trait, x_{ji} is the quantity of the trait j that bull i possesses. Therefore, the econometrically estimated model becomes:

(4) $$\text{PRICE} = \alpha + \beta_1{*}\text{AGE} + \beta_2{*}\text{BEPD} + \beta_3{*}\text{BYGEPD} + \beta_4{*}\text{REAEPD} + \beta_5{*}\text{IMFEPD} + \beta_6{*}\text{LOGNUM} + \beta_i{*}\text{DUMMY}_i + \varepsilon$$

Price is the auction sale price of a bull paid by a cow-calf producer.[16] Age is the age of a bull in days at the time of the sale. Older bulls are expected to be more mature and posses higher breeding capabilities. BEPD is the birth-weight EPD and is linked to potential calving problems. BYGEPD is one of the gain variables[17] (birth to yearling gain). REAEPD is the EPD for rib-eye-area, and IMFEPD is the intramuscular fat EPD. Gain variables and carcass variables (REAEPD, IMFEPD) assist the cow-calf producer when selecting for uniformity. The log of the lot number or sale order is represented by LOGNUM. Traditionally, bulls are expected be sold in the order of quality, highest selling first, making it important to control for quality issues associated with sale order.

[15] Importance refers to which trait bull buyers select explaining the greatest variance in price.
[16] A further description of each variable and relevance is described in Chapter 6 under description of variables.
[17] Pre- and Post-weaning (CGEPD, YGEPD) gain were also used in the regressions, to reduce multicollinearity.

Dummy variables specific to each ranch and ranch dummy variables for each year are included in $DUMMY_i$. The dummy variables assist in the proper specification of the model. Alpha (α) is the intercept term and epsilon (ε) is the regression error. The betas (β) are the estimated implicit values for each trait.

The model described above in equation (4) is one method for estimating the hedonic prices. This model estimates the marginal values by estimating a separate regression equation for each ranch. For the completion of this research two other models for analysis will also be discussed following the interpretation section.

Interpretation

The partial derivative with respect to the trait of interest yields the marginal implicit value of the trait. For example the value of BEPD: the partial derivative of price with respect to BEPD.

(5) $$\frac{\partial \mathrm{Pr}ice}{\partial BEPD} = \beta_2$$

Therefore, the beta (β) coefficients are the parameter estimates associated with the traits. These parameters represent the marginal value of the trait to the buyers of bulls. Specifically, Ranch 1 can interpret the results as the marginal value of BEPD to their buyers. The marginal value of the traits can be compared across the ranches. For example, Ranch 1 $\beta_2 = -100$ can be compared to Ranch 2 $\beta_2 = -200$.

A comparison of the marginal values to separate groups of bull buyers can be made by using F-tests. However, to conduct the F-test for the comparison of parameters, the data must be pooled. The data sets used in this analysis were unbalanced and therefore could not be pooled in a traditional estimation structure. There are two procedures that may be used to conduct the F-tests. The first is to pool the data and use a slope dummy variable approach. The second is to pool the data in the form of a Block Matrix. These two procedures will be discussed in the following sections.

Slope Dummy Variable Procedure

The slope dummy variable procedure is designed the same as the individual regression estimation model. The data from all the ranches in the study are pooled. A slope dummy variable for each ranch is then added to the right-hand side. The ranch dummy variable is multiplied by the variables of interest, to create the slope dummy variable. One ranch is excluded from this procedure creating a control. The econometric model is then:

$$\begin{aligned} PRICE &= \alpha + \beta_1 * AGE + \beta_2 * BEPD + \beta_3 * BYGEPD + \beta_4 * REAEPD + \\ &\beta_5 * IMFEPD + \beta_6 * LOGNUM + \beta_7 * R2 * AGE + \\ &\beta_8 * R2 * BEPD + \beta_9 * R2 * BYGEPD + \beta_{10} * R2 * REAEPD + \\ &\beta_{11} * R2 * IMFEPD + \beta_{12} * R2 * LOGNUM + \varepsilon \end{aligned} \quad (6)$$

For ease of discussion it will be assumed that there are only two ranches included in the data set and no other ranch specific dummy variables exist. The β_i where i = 1….6, are the parameter estimates associated with the traits from the control ranch or in this case Ranch 1. The parameters estimates for Ranch 2 are interaction terms. R2 is the 0, 1 dummy variable for Ranch 2. When this variable is multiplied by the trait an interaction term is created. Ranch 2 beta coefficients are then β_i where I = 8…12.

Caution must be taken when evaluating the implicit value for Ranch 2. The marginal value (parameter) for Ranch 1 is the β_i or the partial derivative with respect to the trait of interest. However, for Ranch 2 the partial derivative is (using BEPD as the trait of interest):

(7) $$\frac{\partial \text{Price}}{\partial \text{BEPD}} = \beta_2 + \beta_8$$

Now the marginal value of BEPD for Ranch 2 is the parameter β_2 for Ranch 1 plus β_8 when R2 equals 1. This creates complications in interpreting and properly restricting the β_i coefficients when conducting the F-tests. This procedure may become complicated as more ranches are added to the data set. Because of these complications, the slope dummy variable approach will not be used in the analysis.

Block Matrix Procedure

For ease of direct interpretation of parameters (β) and for conducting the F-tests, Block Matrix models constructed by Zellner (1962) and Parks (1967) will be used. The original models were for the estimation of unbalanced data sets. They were also designed to correct for Seemingly Unrelated Regression (SUR) and contemporaneous correlation. These models construct a matrix of covariance terms. The across equation covariance terms are located in the upper right off diagonal. For the purposes of this research, there is no reason to assume correlation of error terms across equations (ranches) in the analysis, resulting in the off diagonal being zero. The Block Matrix approach is used here to conveniently estimate the regression coefficient by ranch and test whether those parameters are statistically different. OLS will be used for the analysis. The model in matrix form will be:

(8) $$Y = XB + \varepsilon$$

The vector Y will consist of the prices paid for bulls at each ranch's bull sale; X will be a block matrix of the EPD values for all ranches; B will be the vector of beta (β) coefficients (parameters) to be estimated; and epsilon (ε) will be the error terms. The data for each ranch is represented by the superscript. By expanding this model into matrix form:

$$(9) \qquad \begin{bmatrix} P^1 \\ P^2 \\ P^3 \\ P^4 \end{bmatrix} = \begin{bmatrix} X^1 & 0 & 0 & 0 \\ 0 & X^2 & 0 & 0 \\ 0 & 0 & X^3 & 0 \\ 0 & 0 & 0 & X^4 \end{bmatrix} * \begin{bmatrix} B^1 \\ B^2 \\ B^3 \\ B^4 \end{bmatrix} + \begin{bmatrix} \varepsilon^1 \\ \varepsilon^2 \\ \varepsilon^3 \\ \varepsilon^4 \end{bmatrix}$$

Equation (9) represents the Block Matrix form used for analysis. If the observations from Ranch 1: P^1 are the prices received for bulls; X^1 are the characteristics of bulls; B^1 are the estimated parameters; and ε^1 are the error terms; were extracted for the Block Matrix, equation (9), it would expand and simplify to:

$$(10) \qquad p_{ik} = \sum_{j=1}^{J} \beta_{jk} x_{ijk} + \varepsilon_{ik}$$

Equation (10), in matrix form *i,* represents each individual observation (each bull); *j* represents the specific trait of each bull; and *k* represents the specific ranch (k=1...5). Referring back to equation (9) and extending into equation (10), P^1 is equal to the vector of prices p_{ik} received from Ranch 1. The B vector expands to a vector of β coefficients specific to Ranch 1. The X^1 matrix corresponds to a block of individual observations of the exogenous variables from Ranch 1 used in the regression; x_i is the exogenous variable. The variable hip height[18] was provided by one ranch and included

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[18] Refer to the description of data for a complete list of ranch specific variables. Other variables related to gain were included as well.

on the right hand side. This created a different number of exogenous variables for each ranch, represented by J.

Estimating the B_{jk} using the Block Matrix approach results in the same regression estimates as if the beta coefficients were computed from separate regressions or through the slope dummy variable approach. The empirical model in this form:

$$
\begin{aligned}
(11)\qquad & \text{PRICE} = \alpha + \beta_1{*}\text{R1AGE} + \beta_2{*}\text{R1BEPD} + \beta_3{*}\text{R1BYGEPD} + \\
& \beta_4{*}\text{R1REAEPD} + \beta_5{*}\text{R1IMFEPD} + \beta_6{*}\text{R1LOGNUM} + \\
& \beta_7{*}\text{R2AGE} + \beta_8{*}\text{R2BEPD} + \beta_9{*}\text{R2BYGEPD} + \\
& \beta_{10}{*}\text{R2REAEPD} + \beta_{11}{*}\text{R2IMFEPD} + \beta_{12}{*}\text{R2LOGNUM} + \varepsilon
\end{aligned}
$$

In equation (11), the R (k) indicates the purebred producer. Ranch 1 is R1 and Ranch 2 is R2. Once again, for simplicity, only two purebred breeders will be discussed.

The interpretation is the same as the single equation estimation. The parameter estimate of the trait for a given ranch is the partial derivative for the specified trait from that ranch. Thus, the marginal value of BEPD for Ranch 1 (R1BEPD) is equal to $\beta_{2.}$

$$(12)\qquad \frac{\partial \Pr ice}{\partial R1BEPD} = \beta_2$$

The two procedures outlined above allow for testing restrictions across ranches simultaneously. The β_2 (Ranch 1) can be compared with β_{10} (Ranch 2) with statistical meaning. This allows for insight as to whether different groups of bull buyers value traits differently. The test can be performed on both the slope dummy variable approach and the Block Matrix approach. The difference is computational ease and interpretation of the parameter estimates, and associated t-values from the Block Matrix can be directly interpreted for the specified trait and ranch. Using the slope dummy variable approach the parameters must be compared back to the control trait and ranch. Another advantage to the Block Matrix method is the ranches have different numbers of exogenous variables, specifically ranch specific variables such as hip height. Incorporation these variables would potentially cause problems in the slope dummy variable approach because the variable hip height is continuous. The Block Matrix procedure is used on both the standardized (discussed below) and level values.

Standardization Process

The relative explanatory power or importance of a trait to explain bull price is an important concern to bull producers. The parameters discussed previously do not provide an evaluation of relative importance of each trait. Assume the value of BYGEPD is 100 and the value of REA is 3,200. One trait apparently has a larger value than the other in absolute terms. However, these values are for a 1.0 unit increase in each trait. For BYGEPD the increase of 1.0 unit is more likely if BYGED has a standard deviation of 10 than a 1.0 unit increase for REA with a standard deviation of 0.20. Even though REA apparently has a larger value than BYGEPD, the bull price explanatory power may not be greater. Following Pindyck and Rubinfeld, the variables will be standardized. Therefore, the resulting parameter estimate, standardized parameter, will then determine which trait explains the most variation in price.

> The standardized coefficients then describe the relative importance of the variables in the regression. The standardized coefficients allow for changes in the dependent variable to be measured in standard deviations, for a one standard deviation increase for the independent variable. (Pindyck and Rubinfeld, 1997, p. 98)

Variables can then be ranked by their explanatory power. By comparing the standardized values, the importance of EPDs to different groups of bull buyers can be compared. The information provided by this procedure once again only has relative meaning to each specific ranch; however, the ranking indicates importance of how cow-calf producers value the different traits.

The procedure used is to standardize each variable independently and then re-evaluate the regressions. The variables standardized were: PRICE, BEPD, Gain variables, REAEPD, IMFEPD, AGE, and LOGNUM. Of course, the dummy variables will not be standardized. Mathematically, the variables are standardized by subtracting the mean and dividing by the standard deviation, i.e. $\frac{x-\bar{x}}{\sigma_x^2}$. When the regressions are re-estimated, the β coefficients represent standardized values. The absolute value of the β coefficients can then be compared. The coefficient with the largest absolute value identifies which trait is most important to explain bull prices. The ranking will only be completed on the variables of interest.

Analysis Through Time

The above estimation procedures will be used for the regression analysis of the value of traits through time. The only difference will be that P^1, X^1, B^1, and ε^1 will represent years instead of specific ranches. Thus, P^{2002}, X^{2002}, B^{2002}, and ε^{2002} will represent the prices, data, parameters and errors from the sale year 2002. For comparison of the traits across the years the standardization procedure listed above will also be used. This will allow for a comparison of the importance of traits across years to be made.

Collinear Cattle Traits

By construction, the animal weight EPDs are collinear. The birth-weight (BW) of an animal plus the gain of the animal to 205 (g_{205}) days or weaning is equal to the weaning weight (WW), WW= BW + g_{205}. Similarly the birth-weight plus the gain from birth to 365 days (g_{365}) or yearling age is equal to the yearling weight (YW), YW= BW + g_{365}. Therefore, it is not surprising that birth, weaning, and yearling weight EPDs are collinear.

The collinearity then leads to the usual statistical problems in regression analysis. Previous studies did not account for the collinearity of these traits. To address this problem, birth-weight, the gain between birth and weaning (yearling), WW- BW = g_{205} (YW- BW = g_{365}) are used as independent variables in the regression model rather than birth and weaning (yearling) weight.

In the analysis, pre- and post-weaning gains are used as exogenous variables. Pre-weaning gain is equal to g_{205}; post-weaning gain is equal to g_{365} - g_{205}. Pre- and post-weaning gain are two independent variables.

From previous discussion the simplified hedonic model is:

(13)
$$\begin{aligned} PRICE &= \alpha + \beta_1 * AGE + \beta_2 * BEPD + \beta_3 * BYGEPD + \\ &\beta_4 * REAEPD + \beta_5 * IMFEPD + \beta_6 * LOGNUM + \\ &\beta_i * DUMMY_i + \varepsilon \end{aligned}$$

Which for discussion here is further simplified to equation (14):

(14)
$$\mathrm{PRICE} = \alpha + \beta_2 * \mathrm{BEPD} + \beta_3 * \mathrm{YGEPD}$$

Because YEPD is equal to BEPD plus g_{365} (YEPD = BEPD + g_{365}), the model can be rewritten as equation (15):

(15) $$PRICE = \alpha + \delta_2 * BEPD + \delta_3 * (BEPD + g_{365})$$

By rearranging equation (15) we get:

(16) $$PRICE = \alpha + (\delta_2 + \delta_3) * BEPD + \delta_3 * g_{365}$$

This results in the coefficient of BEPD to be over (under) estimated as ($\delta_2 + \delta_3$) is greater (less) than δ_2. If the true marginal value for BEPD is expected to be β_2 which is equal to δ_2, then β_2 is less (greater) than ($\delta_2 + \delta_3$). The collinearity will lead to higher standard errors and decreasing t-values. Therefore, we may reject the significance of a variable that does in fact impact the sale price of a bull.

In this case, three independent variables are created: birth to weaning weight (pre-weaning), weaning to yearling weight (post-weaning), and birth to yearling weight. Cow-calf producers may make different selections based on when and how they market calves.[19]

[19] Because of different marketing strategies some producers sell calves at weaning approximately 205 days of age, while others background and sell the calves at closer to 365 days of age.

CHAPTER 6

DATA

Description of Data and Variables across Bull Producers

Cross-sectional data was collected from four registered Red and Black Angus producers from across the Western United States. These producers have a reputation of selling high quality bulls. Data was also provided by a ranch that specializes in selling cross-bred bulls. The data was collected and assembled by the ranch staff from production auction sales and was submitted in electronic form.[20] The data provided 3,063 observations for the production sale years 2005, and 2006. The data collected contained actual information on birth-weight, weaning weight, yearling weight, hip height, and scrotal measurement. The data also consisted of related growth, intramuscular fat, and rib-eye-area EPDs. The bull's sale price, sale lot number, and birth date were also collected.[21] Observations that were missing information were deleted from the data set.

Bull observations that were outside the selected price ($1,500 to $30,000) range were deleted from the data set. Bulls with an extremely low price are considered to be no-sale bulls. These are bulls that did not sell in the sale. Many times in purebred bull sales the, purebred breeder will set a floor price and a ranch representative "purchases" all bulls that do not meet or exceed the price floor. Thus every bull in the data set has a

[20] The data is the information provided in sale catalogs by purebred producers for the buyers. This data is assumed to be correct. At production sales representatives from the Angus Association are present to monitor the accuracy of the EPD information provided.
[21] Only data pertaining to the EPDs of interest were used in the regression analysis.

price and no-sales bulls cannot be distinguished from bulls sold. After interviews with the ranches, no-sale prices were believed to be about $1,500; therefore, bulls selling for $1,500 or less were excluded from the data. Bulls with an excessively high price were also eliminated from the data set. Bulls with excessive high prices are generally purchased for and by purebred breeders. In most cases, a limited number of potential buyers of these higher valued bulls are provided with more information than is published in the sale catalog. These bulls were expected to be bulls whose price exceeded $30,000. There were approximately 150 low priced bulls and 10 high priced bulls excluded from the data set.

<u>Description of the Ranches</u>

Ranch 1 provided 769 observations from spring 2005 and 2006 production sales. This ranch sells registered Black Angus bulls at approximately 18 months of age. These are bulls that were born in the fall of the year. The average selling price for Ranch 1 was $5,172. Ranch 1 has a reputation for being the leader of genetic improvements in the Angus breed. They may provide cattle that consistently have higher quality traits.

Because Ranch 1 is expected to produce the leading genetics for the Angus breed, they may also be selling into a different target market than the other four ranches. Instead of selling most of their bulls into cow-calf operations, it is possible that the bulls are being sold to other purebred producers who may have stricter genetics selection criteria and who may be willing to pay a higher price. Purebred producers supply the genetics to cow-calf producers. If in fact they are selling into a different target market and specializing to fit the needs of other purebred producers and not commercial breeders, these factors need to be considered when analyzing the results. The results could be representative of purebred producer preferences instead of cow-calf producers.

Ranches 2, 3, 4, and 5 are expected to be producing bulls primarily for the cow-calf or commercial market. The bulls sold by these ranches are for permanent pasture breeding of commercial cattle. These ranches then have similar breeding programs. The cross-bred ranch, Ranch 5, may have a slightly different approach in breeding since they are trying to optimize heterosis[22] across different breeds.

Ranch 2 provided 482 observations on Red and Black Angus Bulls. They are one of the genetic leaders in the Red Angus breed, and they sell quality black cattle as well. Bulls born in the spring of 2003 and 2004 were sold as yearlings in the spring of 2005 and 2006 production sales. The average selling price of the bulls in both sales was $2,877. The Red Angus market is smaller, with fewer buyers, and fewer cattle. Since these bulls will be sold to cow-calf producers as inputs, it is assumed that across all the breeds, cow-calf producer have similar selection criteria. It was speculated that the red bulls would bring a premium for Ranch 2, since their reputation was built as a Red Angus breeder.

Ranch 2 openly states they are breeding for low birth-weight bulls. Their average birth-weight EPD is +1.09 with the next closest being a +1.49 from Ranch 1. By selling low birth-weight bulls the ranch may be attracting customers who are willing to make tradeoffs with other traits.

Ranch 3 sold the most purebred bulls in the data set. They provided 1,073 observations from two separate sales. The first sale was from the fall of 2005, and the

[22] Heterosis is one of the goals of crossbreeding that increases vigor, size, and other attributes.

second sale was in the spring of 2006. The average selling price of these bulls was $3,572.

The fall sale is the original sale for this ranch. The important difference is the fall sale is primarily selling herd bulls or bulls that will be used on older cows. The spring sale, by contrast, targets the commercial buyers who will be using the bulls on first calf heifers. As a result, buyers' emphasis may be different at the two sales.

Ranches 1, 2 and 3 are selling bulls on national and international markets. This indicates a wide variety of buyers. They must attempt to maintain a breeding program that is widely accepted. Thus, they are breeding and selling into multiple target markets.

In contrast, Ranch 4 sells to a local market of buyers. They sold 275 Black Angus bulls from 2005 and 2006 spring sales with and average price of $3,212. Their local market, as explained by the owners, "is selling bulls to buyers who want sound bulls able to travel rough terrain and produce calves with a low birth-weight and high gain." From discussions with Ranch 4, they indicated that their bull buyers are facing increasing labor costs. To offset or reduce these costs, their buyers focus on increasing calving ease, i.e. lower birth-weights.

Ranch 5 is the cross-bred ranch and sold 538 cross-bred bulls in spring 2005 and 2006 sales. The average selling price of the cross-bred bulls was $2,931. Full information on breed composition was provided. Buyers of cross-bred bulls may not be as sensitive to selective breeding practices as those of purebred bulls. If the cross-bred buyers value the information provided by carcass traits, then the carcass EPDs should influence bull prices.

The EPDs used for the Ranch 5 analysis differ from the EPDs of the other four ranches. The first four ranches have breed specific EPDs and refer to the Red or Black Angus herd averages.[23] The EPDs used by Ranch 5 are all breed EPDs and are designed to compare animals of the different breeds.

Description of Variables

All five ranches provided information on the EPD variables of interest, birth-weight, gain, and carcass quality. Information was also provided on as date of birth, sale price, and sale lot number. The following section will describe the variables and their relevance to the regressions. The four main EPD variables of interest for this analysis were birth-weight, gain and the two carcass variables, rib-eye-area and intramuscular fat. Expected variable signs are in Figure 1.

The sale price of a bull was the dependant variable in the analysis. This was the price for which a bull was sold through the purebred producers' annual production sale. The Annual production sale is auction format, and bulls are sold individually.

Birth-weight EPD (BEPD) helps the producer forecast the birth-weight of the bull's progeny. The BEPD is measured in pounds. This variable is expected to have a negative correlation with the sale price of a bull. Increasing birth-weight may lead to increased mortality rates decreasing a cow-calf producer's expected profits (Chvosta, Rucker, and Watts, 2001). The producer will try and reduce the risk of mortality by

[23] Dummy Variables used to control for Red and Black Angus correct for the different breed averages in the regression. It is assumed that buyers understand and can interpret the EPDs across red and black bulls. Also the dummy variable will separated out the buyers of red vs. black bulls.

purchasing low birth-weight bulls. Heavy calves often have difficulty at birth, requiring assistance and in extreme cases veterinary service.

Figure 1. Description of Variables and Expected Sign.

Variable Name	Abbreviation	Description	Actual/EPD Value	Expected Sign
Price	PRICE	The sale price the bull	Actual	N/A
Birth EPD	BEPD	Birth-weight	EPD	Negative
Gain EPDs				
Pre-Weaning	CGEPD	Gain from birth to 205 Days	EPD	Positive
Post-weaning	YGEPD	Gain from 205 days to 365 Days	EPD	Positive
Birth to Yearling Gain	BYGEPD	Gain from Birth to 365 Days	EPD	Positive
Intramuscular Fat	IMFEPD	Intramuscular Fat EPD	EPD	Positive
Rib-eye-area	REAEPD	Rib-eye-area EPD	EPD	Positive
Age	AGE	Age in Days at time of Sale	Actual	Positive
Log Lot Number	LOG NUM	Log of the Lot Number or Sale Order	Actual	Negative
Year Dummy 2005	Ranch#-DUM05	Dummy Variable for 2005 Production Sale Ranch Specific	Actual	N/A
Year Dummy 2006	Ranch#-DUM05	Dummy Variable for 2006 Production Sale Ranch Specific	Actual	N/A
Hip Height	HPH	Hip Height	Actual	Negative
Red Angus Dummy	RAD	Red Angus Bull Dummy Variable	Actual	Positive
Ranch 3 Dummy	R3DUMMY	Dummy Variable for Ranch Three Composition	Actual	N/A
% Not Angus	%NOTANG	Percent Breed Composition Not Black Angus	Actual	Negative

Birth to yearling gain EPD (BYGEPD) is a variable that describes the overall gain of the animal from birth to 365 days in age and is calculated by subtracting the birth-weight BEPD from the yearling weight EPD. This variable is created to potentially decrease the collinearity between the weight EPDs. This variable is also measured in pounds. The gain of the animal between birth and either weaning weight or yearling weight is a large factor in the profit function of the producer. Producers generally sell their calves by the pound at weaning or yearling age. The heavier the animal, the more revenue generated per animal. Since higher BYGEPD is widely viewed as profit enhancing, bulls with higher BYGEPD are expected to sell for higher prices.

Two other variables were used to evaluate gain, pre-weaning gain (CGEPD) and post-weaning gain (YGEPD). The CGEPD is the gain of the animal from birth to weaning or approximately 205 days of age. To create this variable the BEPD was subtracted from the weaning weight EPD (WEPD). The post-weaning gain is a measure of the gain of the animal from weaning (205 days) to yearling adjusted to 365days of age. The WEPD is subtracted from the yearling weight EPD (YEPD). Because cow-calf producers sell calves at different times, the separate aspects of the gain need to be evaluated as to which gain (e.g. pre (post) weaning or BYGEPD) is more valuable to buyers of bulls.

The carcass EPD variables are predictors of the progeny's performance at the time of slaughter. As producers selectively breed for carcass quality, they should potentially be breeding for more uniform calves. Selective breeding for uniformity reduces the probability of producing low quality livestock. This in turn reduces the number of animals that are undesirable to the consumer. Once again these are variables that determine the quality of the Prime Rib (or other beef cuts) that the consumer will eat. Because high carcass quality is valued by the consumer these traits are expected to be positively correlated with the price of a bull.

Rib-eye-area EPD (REAEPD) is the measure of potential rib-eye-area of the animal. This is measured in square inches. The rib-eye is one of the most expensive and desired cuts of beef. Intramuscular Fat EPD (IMFEPD)[24] is a measure of the amount of marbling throughout the muscle. This is a combination of measurement of USDA yield score and the percent of fat in the muscle. The intramuscular fat of an animal ultimately determines the tenderness and flavor of the meat produced.

In many sales, the top bulls are sold at the beginning of the sale. This makes it important to control for the sale order of the bulls sold, to evaluate whether there is a difference between bulls sold in the beginning and those at the end. The sale lot number or sale order variable was used to control for unobserved quality differences. Some of the ranches had breaks in the sale order due to selling other cattle (i.e. females) separate from the bulls of interest. This created large breaks and a noncontiguous stream of lot numbers. In these cases, bulls were sorted by lot number and then a continuous sale order variable was created. It is expected that the marginal difference (δ_{beg}) between Bull 1 and Bull 2 will be greater than the marginal difference (δ_{end}) between Bull 200 and Bull 201. Since the marginal value difference is expected to decrease as lot number (sale order) increases, the log of lot number (LOGNUM) was used to evaluate the non-linear aspects. Bulls sold later in the sale were expected to sell for less than bulls sold earlier.

The age variable was calculated in days. It described the age of the bull at the time of the sale. The date of sale was subtracted from April 1st for each year of sale. This gave the age of the bull in days, with an average age of 15 to 18 months old. Age is important because older bulls are more mature and are expected to have higher breeding

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[24] Intramuscular fat and marbling are the same measurement and are used interchangeably.

capacity than younger bulls. However, the sale of a bull that is too old may indicate that there is a problem that caused the bull to not be sold in earlier sales.

Dummy variables specific to each ranch and sale year were included in the regressions. These variables accounted for marketing factors specific to each sale year (2005 and 2006) as well differences in the ranches.

Some of the ranches also provided additional data that was used in the regressions. These variables were added to the regression to assist in correct model specification. The hip height variable (HPH) measures the height of the bull in inches. This is an indicator as to the frame size of the bull. This variable was provided by Ranch 1. A larger frame bull is expected to be discounted.

Ranch 2 sold both Red and Black Angus bulls in their sale. A dummy variable *RAD* was created to control for the differences in sale prices between red and black Angus. This was done to account for the difference in buyers of red bulls and the buyers of black bulls. Because Ranch 2 has a reputation for selling Red Angus it was expected that the red bulls would bring a premium over the black bulls. Red bulls took on the value of 1, and black bulls had a value of 0.

The Ranch 3 sale is a composite of two ranches; an indicator variable was created to account for the different ranches *R3DUMMY*. For this analysis it was not important which ranch the bulls originated, however, by omitting the variable the model is assumed to suffer from specification errors.

Only year-specific dummy variables were used in the Ranch 4 or Ranch 5 regressions. Ranch 5 was the cross-bred ranch. A variable that measured the percent of

Black Angus was included. It is expected in the cattle industry that black hided cattle bring a premium. With this being the case it is then important to account for the breed composition percent of Black Angus.

Description of Data for Ranch 2 and Ranch 5, 2002-2006

Ranch 2 and Ranch 5 provided additional data from annual production sales from 2002 through 2006. Ranch 2 provided 1,763 observations and Ranch 5 provided 1,814 observations. The variables used in the time regression analysis are the same as the variables explained in the across-ranch analysis.

One difference in variables was the ranch and sale year specific dummy variable was replaced by a sale year specific dummy variable. This variable represents the different sale years across Ranch 2 and Ranch 5. Another difference is that the regressions are evaluated on the ranches individually. Thus Ranch 2 is evaluated for the years 2002 through 2006 and Ranch 5 is evaluated similarly.

Summary Statistics

Ranches 1, 2, 3, 4, and 5, Years 2005 & 2006

Table 1 lists the summary statistics of the variables used in the regression analysis for the four purebred producers and the cross-bred producer. The mean value and the standard deviation are listed for each variable specific to each ranch. The averages are the averages across the ranches for the sale years 2005 and 2006 combined.

Table 1. Summary Statistics Four Purebred Producer and One Cross-bred Producer.

	Ranch 1	Ranch 2	Ranch 3	Ranch 4	Ranch 5
Variable	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)
Price	5172.63	2877.55	3572.60	3212.73	2931.86
	(2067.83)	(1300.58)	(1116.60)	(1683.36)	(1094.39)
Birth EPD	1.84	1.10	2.10	1.49	1.46
	(1.33)	(1.68)	(1.72)	(1.16)	(1.51)
Gain EPDs					
Pre-Weaning	42.67	37.32	40.66	37.12	39.07
	(5.06)	(7.34)	(6.46)	(5.83)	(5.72)
Post-weaning	44.02	36.50	37.35	33.56	32.64
	(3.55)	(8.52)	(6.39)	(6.27)	(7.06)
Birth to Yearling	86.69	73.82	78.02	70.68	71.72
	(7.02)	(13.99)	(10.92)	(9.73)	(10.86)
Carcass EPDs					
Intramuscular Fat	0.31	0.14	0.20	0.04	-0.09
	(0.15)	(0.21)	(0.14)	(0.13)	(0.16)
Rib-eye-area	0.40	0.37	0.22	0.10	0.45
	(0.21)	(0.23)	(0.21)	(0.18)	(0.17)
Log Lot Number	5.16	4.54	6.03	3.98	5.85
	(0.97)	(1.00)	(1.16)	(0.96)	(0.25)
Age	582.74	444.08	514.27	398.15	397.75
	(15.81)	(103.31)	(145.65)	(14.01)	(40.72)
Hip Height	21.63				
	(25.38)				
Ranch 3 Dummy			0.57		
			(0.49)		
Breed Composition					
Red Angus Dummy		0.39			
		(0.49)			
% Black Angus					0.35
					(0.20)
% Red Angus					0.15
					(0.13)
% Simmental					0.23
					(0.16)
Observations	769	414	1073	275	532

The average ranch birth-weight EPD (BEPD) had a range of +1.1 to +2.1 pounds with a standard deviation range from 1.16 to 1.72. On average the bulls in this study are expected to sire calves up to 2 pounds heavier at birth than the Angus breed average.[25]

On average EPDs on bulls from these ranches suggest a birth to yearling progeny gain of 70 to 86 pounds more than the typical bull, with a standard deviation of 7 to 14. The average increased pre-weaning progeny gain of the bulls is +40, with a standard deviation of 6, and the post-weaning progeny gain is about +35, with a standard deviation from 3.55 to 8.52. The bulls in this analysis are expected to gain more than the Angus breed average. On average both of the carcass variables indicate the bulls in this study have higher carcass quality attributes than the Angus herd average. The average age of the bulls was between 15 and 18 months of age (398 to 585 days). The remainder of the ranch specific variables will be left to the reader.

Ranch 2 and Ranch 5, Years 2002—2006

Ranch 2 had a nominal sale price average from 2002 to 2006 from $2,100 to $3,500. This price was the average of purebred Black and Red Angus bulls. The average BEPD through this time period was +1 to +1.67, standard deviation of 1.42 to 1.65. On average the bulls from this Ranch were expected to produce progeny that gain 35 to 40 pounds more in both the pre- and post-weaning time frames, with a standard deviation 6.8 to 8.6. The overall average expected gain of progeny from birth to yearling age was 72 pounds more, with a standard deviation of 10.5 to 14.20. On average these bulls were

[25] Crossbred EPDs are measured against an all breed EPD average. The crossbred bulls were about 1.5 pounds heavier than the all breed average. The remaining EPD statistics pertaining to the crossbred bulls can be interpreted similarly.

sold in sale at approximately 15 months of age, with about 40% being Red Angus Bulls. The summary statistics can be found in Table 2.

Table 2. Summary Statistics Purebred Bull Producer 2002-2006.

Variable	**2002** Mean (Std. Dev)	**2003** Mean (Std. Dev)	**2004** Mean (Std. Dev)	**2005** Mean (Std. Dev)	**2006** Mean (Std. Dev)
Price	2829.20	2113.32	2271.85	2660.54	3528.82
	(1793.73)	(1398.78)	(1148.99)	(814.86)	(1735.81)
Birth EPD	1.67	1.28	0.98	.89	1.08
	(1.48)	(1.54)	(1.42)	(1.66)	(1.61)
Gain EPDs					
Pre-Weaning	35.92	38.93	38.40	38.42	37.46
	(6.10)	(5.72)	(6.73)	(7.02)	(7.701)
Post-weaning	37.78	35.28	36.91	37.82	36.30
	(6.86)	(7.04)	(7.98)	(8.86)	(8.07)
Birth to Yearling	73.70	74.20	75.31	73.24	73.76
	(11.15)	(10.50)	(12.58)	(13.85)	(14.22)
Carcass EPDs					
Intramuscular Fat	0.06	0.10	0.14	0.16	0.17
	(0.18)	(0.20)	(0.23)	(0.18)	(0.22)
Rib-eye-area	0.26	0.27	0.32	0.35	0.41
	(0.21)	(0.20)	(0.24)	(0.23)	(0.23)
Log Lot Number	5.27	5.29	4.67	4.70	4.16
	(0.98)	(0.98)	(0.96)	(1.04)	(0.95)
Age	409.33	397.46	404.12	402.61	413.28
	(39.39)	(38.33)	(22.65)	(22.54)	(32.01)
Red Angus Dummy	0.48	0.41	0.41	0.36	0.31
	(0.50)	(0.49)	(0.49)	(0.48)	(0.46)
Observations	526	537	286	244	170

Ranch 5 sold cross-bred bulls for a nominal average ranging from $2,000 to $3,000. The cross-bred bulls on average are expected to produce progeny with a birth-weight of +1.36 to +1.80 pounds heavier, standard deviation 1.30 to 1.70. These bulls on average will produce calves 35 to 40 pounds heavier prior to weaning, standard deviation 5.5 to 6.2, and will gain an additional 30 pounds post-weaning on average, standard deviation 6.86 to 8.68. This accounts for an average birth to yearling gain from 65 to 70 pounds, standard deviation 6.5 to 7.6. Theses bulls are also approximately 15 months of age at the time of sale. The breed composition of these bulls is on average 30-35% Black Angus, 15-20% Red Angus, and 15-25% Simmental. On average 50% of the breed composition is not Red or Black Angus. The remainder of the summary statistics can be found in Table 3.

Table 3. Summary Statistics Cross-Bred Bull Producer 2002-2006.

	2002	**2003**	**2004**	**2005**	**2006**
Variable	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)
Price	2316.19	1884.77	2199.25	2653.63	3164.70
	(916.20)	(995.97)	(678.71)	(881.37)	(1212.49)
Birth EPD	1.80	1.78	1.36	1.54	1.41
	(1.65)	(1.69)	(1.28)	(1.51)	(1.52)
Gain EPDs					
Pre-Weaning	34.66	35.93	37.49	39.28	38.87
	(5.73)	(6.24)	(6.20)	(6.01)	(5.48)
Post-weaning	29.63	30.09	32.65	31.93	33.32
	(7.67)	(6.97)	(6.61)	(7.49)	(6.59)
Birth to Yearling	64.28	66.03	70.13	71.21	72.18
	(11.48)	(11.14)	(10.56)	(11.43)	(10.30)
Carcass EPDs					
Intramuscular Fat	0.15	0.16	0.08	0.12	0.07
	(0.16)	(0.17)	(0.17)	(0.19)	(0.13)
Rib-eye-area	0.36	0.38	0.39	0.42	0.48
	(0.21)	(0.20)	(0.19)	(0.18)	(0.17)
	5.32	5.26	4.46	4.53	4.70
Log Lot Number	(0.98)	(0.98)	(0.96)	(0.96)	(0.97)
Age	388.74	394.04	391.45	407.25	392.20
	(20.09)	(39.67)	(17.07)	(64.07)	(16.40)
Breed Composition					
% Black Angus	0.29	0.28	0.36	0.34	0.35
	(0.24)	(0.21)	(0.21)	(0.23)	(0.18)
% Red Angus	0.20	0.19	0.16	0.16	0.14
	(0.21)	(0.20)	(0.15)	(0.15)	(0.13)
% Simmental	0.14	0.19	0.24	0.21	0.24
	(0.17)	(0.22)	(0.16)	(0.16)	(0.17)
% Not Angus	0.51	0.53	0.48	0.50	0.50
	(0.18)	(0.17)	(0.18)	(0.15)	(0.14)
Observations	533	518	231	242	290

CHAPTER 7

REGRESSION RESULTS: ACROSS RANCH ANALYSIS

Using the combined 2005 and 2006 data sets, trait values were estimated across the ranches. To avoid multicollinearity between the gain traits two separate regression specifications were completed. The first regression was a model that included the gain of the animal from birth to yearling age 365 days. The second regression model contained the pre- and post-weaning gain variables. These two variables are considered to be separate measurements of the segments of calf gain. The parameters, which are estimates of the trait marginal values, are compared across the ranches to evaluate spatial related differences. The two model specifications will then be standardized to compare the explanatory power of the traits on price (importance). The explanatory power of BEPD, gain, IMF and REA is then ranked. Differences of importance across the purebred bull buyers will be evaluated.

Across Ranch Analysis Results

The following results are not standardized and can be interpreted as the marginal value of the trait. The OLS regression estimated parameters for the value of bull's traits are presented in Tables 4 and 5. Table 4 presents the results for the regression containing birth to 365 day (yearling) gain. Table 5 presents the results containing the variables birth to 205 days gain and 205 days to 365 days gain. These two variables represent pre-and post-weaning gain.[26] The estimated parameters have the expected sign and are statistically significant at usual accepted levels, except for intramuscular fat and age for some ranches. Post-weaning gain was not significant for Ranches 1, 2, and 4.

The parameter estimates for birth-weight decrease the dependant variable from 75 to 280. On Ranch 1 the parameter estimate suggests bulls prices are expected to decline by $250 for each pound increase in birth-weight EPD. Ranch 4 can expect bull prices to decrease $286 for every additional pound of birth-weight EPD. In most auction sales this is approximately one bid increment. As the data indicates and as Ranch 4 stated, their bull buyers discount bulls with expected high birth-weights. The buyers of bulls from Ranch 2, and Ranch 3 discount bulls about $100 for every addition pound of birth-weight. The negative birth-weight parameter supports the contention that producers prefer lower birth-weight bulls to reduce labor costs.

The parameter estimate for birth to yearling gain is between 20 and 56 across the ranches. Commercial cattle are usually sold by the pound; as expected the estimated parameter for gain is positive. Ranch 3 indicated that their buyers were more sensitive to purchasing cattle with high gain potential. They explained "we sell cattle to producers from across the United States and consistently these buyers are concerned with the ability of the animal to gain."

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[26] The results for the variables were similar in Table 4 and Table 5. Only the gain results will be discussed individually.

Table 4. Across Ranch Analysis—BYGEPD

Variable	Ranch 1 Coefficient (t-value)	Ranch 2 Coefficient (t-value)	Ranch 3 Coefficient (t-value)	Ranch 4 Coefficient (t-value)	Ranch 5 Coefficient (t-value)
Birth EPD	-250.356	-110.41	-94.442	-286.63	-75.133
	(7.54)**	(3.39)**	(4.29)**	(4.83)**	(2.30)*
Gain EPD (BYGPD)	26.118	19.46	30.803	56.033	21.422
	(4.03)**	(4.62)**	(8.77)**	(7.68)**	(4.61)**
Intramuscular Fat	3,247.63	856.55	423.164	504.479	1,135.51
	(10.44)**	(2.68)**	(1.54)	(0.91)	(2.90)**
Rib-eye-area	1,794.89	1584.29	852.762	2,083.17	1,204.24
	(8.04)**	(6.65)**	(5.07)**	(5.50)**	(4.12)**
Age	-3.322	13.332	0.091	13.332	0.758
	(1.23)	(5.71)**	(0.24)	(2.52)*	(0.61)
Log Lot Number	-1,243.70	-191.82	-425.664	-458.895	-636.956
	(25.60)**	(3.36)**	(9.80)**	(5.83)**	(2.47)*
Year Dummy 05	30,531.25	-5519.20	2,530.35	-5,120.98	3,591.92
	(8.71)**	(4.22)**	(3.40)**	(2.19)*	(2.23)*
Year Dummy 06	8,018.33	-4877.82	2,194.63	-5,532.80	4,022.67
	(4.30)**	(3.71)**	(3.07)**	(2.36)*	(2.44)*
Hip Height	-407.272				
	(7.71)**				
Red Angus Dummy		574.39			
		(3.99)**			
Ranch 3 Dummy			-159.401		
			(2.14)*		
% Not Angus					1,306.26
					(2.80)**
Observations	3063				
R-squared	0.59				

Absolute value of t statistics in parenthesis
* significant at 5%; ** significant at 1%

Table 5. Across Ranch Analysis—Pre (Post) Weaning Gain

Variable	**Ranch 1** Coefficient (t-value)	**Ranch 2** Coefficient (t-value)	**Ranch 3** Coefficient (t-value)	**Ranch 4** Coefficient (t-value)	**Ranch 5** Coefficient (t-value)
Birth EPD	-254.146 (7.68)**	-121.06 (3.27)**	-91.921 (4.19)**	-276.242 (4.68)**	-80.465 (2.44)*
Gain EPD Pre-Weaning	36.004 (3.82)**	11.96 (1.14)	39.227 (6.32)**	121.24 (9.46)**	13.503 (1.39)
Post-Weaning	11.156 (0.91)	24.75 (3.09)**	22.472 (3.65)**	3.179 (0.28)	27.457 (3.44)**
Intramuscular Fat	3,353.76 (10.55)**	841.70 (2.50)**	477.996 (1.74)	357.793 (0.65)	1,094.07 (2.80)**
Rib-eye-area	1,801.82 (8.12)**	1562.70 (6.20)**	878.307 (5.23)**	1,786.94 (4.71)**	1,176.97 (4.04)**
Age	-3.236 (1.20)	13.09 (5.07)**	0.128 (0.34)	9.702 (1.83)	0.726 (0.59)
Log Lot Number	-1,248.89 (25.81)**	-191.87 (3.19)**	-421.783 (9.76)**	-415.451 (5.29)**	-689.384 (2.63)**
Year Dummy 05	30,852.59 (8.84)**	-4,816.18 (3.71)	2,411.29 (3.25)**	-4,458.51 (1.92)	4,032.28 (2.41)*
Year Dummy 06	8,179.01 (4.41)**	-4170.86 (3.20)**	2,091.34 (2.94)**	-4,934.57 (2.12)*	4,462.68 (2.62)**
Hip Height	-410.01 (7.81)**				
Red Angus Dummy		536.91 (3.38)**			
Ranch 3 Dummy			-157.326 (2.12)*		
% Not Angus					1,322.16 (2.85)**
Observations	3063				
R-squared	0.59				

Absolute value of t statistics in parenthesis
* significant at 5%; ** significant at 1%

The results for pre- and post-weaning gain are in Table 5. The differences in significance may indicate that the buyers of purebred bulls sell calves at different ages, as weanlings or as yearlings. Selling calves at different ages leads us to believe that cow-calf producer value pre- and post-weaning gain differently. Pre-weaning gain was statistically significant for Ranches 1, 2, and 4. The value of pre-weaning gain ranges from $25 to $120. The buyers of bulls from Ranch 4 value the pre-weaning gain $121. The parameter estimate for Ranch 4 pre-weaning gain stands out in the results. Inexplicably this parameter estimate is much higher than analogous parameters of the other ranches. Ranch 5 results indicate that bull buyers value post-weaning gain with a significant parameter estimate of 27. Thus, they are concerned with gain of the calves after weaning.

Correlation between the gain traits may cause the differences in estimated parameters. Comparing the variance of BYGEPD with the sum of the variances of pre- and post-weaning gain is an indication of correlation between the gain traits. The sum of the variance of the two independent variables is equal to the sum of the variance of each variable. If the variance of BYGEPD is exactly equal to the summation of the variance of pre- and post-weaning gain, then the covariance of pre- and post-weaning gain must equal zero. The sum of the variances of pre- and post-weaning gain EPDs approximately equals the total gain EPD, indicating low levels of covariance or correlation.

Ranch 3 provides intriguing results as both pre- and post-weaning gain are statistically significant. Their buyers value pre-weaning gain about $40 and post-weaning gain $23. They do sell bulls to large variety of buyers.

The parameter estimates for carcass traits must be evaluated with caution because the scale of the carcass trait variables. The standard deviation for IMF and REA is about 0.20. A unit increase in carcass quality is about 5 standard deviation changes in the carcass quality variables. Therefore, the parameter estimates for carcass quality are not unreasonable given the scale of the carcass quality variables.

The parameter estimates for increased carcass quality, rib-eye-area range from 800 to 2,000 across the ranches, in Tables 4 and 5, and are statistically significant. The parameter estimates for intramuscular fat range from 400 to 3,200. These parameters are significant for ranches 1, 2 and 5. The positive parameters of the carcass traits and the statistical significance indicate that cow-calf producers do value the ability to improve carcasses.

The age variable parameter estimate for Ranch 2 was statistically significant and positive. They sell yearling bulls, in the spring of the year, prior to breeding in late March or early April. Because cow-calf producer turn bulls in with the cows for breeding starting in mid May the age and maturity of the bull is a large factor. Ranch 2 results indicate that bull buyers do value older bulls. The other ranches also have spring production sales. However, the insignificant parameter for age may indicate the other ranches hold their production sales earlier in the spring or their buyers may breed cows later.

The log of the lot number or sale order was used to evaluate the non linear affects of the sale order.[27] The results support the perception of bull buyers that better bulls sell earlier in the sale. As the lot number of a bull increases the price of a bull declines.

The hip height (a proxy for frame size) was provided by Ranch 1. For every additional inch of hip height the price of a bull decreased $407. This indicates that larger cattle are discounted and cow-calf producer are breeding for more moderately framed cattle.

Ranch 5, the cross-bred ranch provided information on the breed composition. The parameter for breed composition is represented by the percent not Black Angus. The parameter estimate is positive 1,306 for percent not Black Angus. At first, this seems contradictory to the cattle industry, as black hided cattle generally sell for a premium. However, assume there are two cross-bred bulls, a black bull and a white bull. The black, bull by composition, contains more Black Angus influence. Holding all else constant, if these two bulls have the same IMF and REA EPDs, the white bull may be worth more. This is because Black Angus cattle are expected to possess higher quality carcass traits than other breeds. The white bull with less Angus influence but the same carcass EPD is then considered to have higher genetic merit relative to other white bulls, than the black bull. This anomaly then causes the buyers of cross-bred bulls to place a higher value on bulls with less Black Angus influence and higher quality carcass traits.

Year and ranch dummy variables were used in the regression to control for unobservable factors. The year component of the dummy variable accounts for cattle industry factors. Thus, a difference in cattle prices, feed prices and other market factors

[27] Log of lot number and sale order are considered the same variable across the ranches.

between 2005 and 2006 are taken into consideration. The ranch component of the dummy variable adjusts for the reputation and spatial differences across the separate bull producers.

Other variables such as Red Angus Dummy (RAD), and Ranch 3 Dummy, were significant. The results are not considered to add any relative information to this study and will be left to the reader. A complete set of results can be found in Tables 4 and 5.

Across Ranch Comparisons

The parameters are the estimated marginal values of the traits to buyers of bulls. The marginal values are comparable across the ranches. For example the rib-eye-area marginal values range from $80 to $200.

F-tests can be used to evaluate the differences in the parameters across the ranches. The big-block matrix structure conveniently allows the parameters to be restricted and tested for statistical differences. The procedure distinguishes if the marginal values from all the ranches are the same.

The parameters for the traits of interest were restricted to be equal across ranches. Table 6 presents the F-tests for each trait restriction among purebred producers. The null hypothesis is that the parameter estimates for the trait is equal across the ranches.

The F-test results indicate that the parameter estimates across the purebred ranches is statistically different, rejecting the null hypothesis. The four main variables of interest, BEPD, BYGEPD, IMF, REA, were all statistically different across the ranches at the 1% level. The critical values for the F-tests are listed at the bottom of Table 6. The pre-weaning gain variable was also statistically different across all the purebred ranches. The post-weaning gain variable indicated that cow-calf producers do not value this trait differently across the purebred ranches, failing to reject the null.

Table 6. F-Test Results Regression Coefficients

	Purebred Producers	
	F-Stat	(P Value)
Variables		
Birth-weight	7.30	(0.0001)
Birth to Yearling Gain	6.13	(0.0004)
Pre-Weaning Gain EPD	15.47	(0.0000)
Post-weaning Gain EPD	1.07	(0.3623)
Intramuscular Fat	17.58	(0.0000)
Rib-eye-area	5.74	(0.0006)
Number of Restrictions	3	
Degrees of Freedom	3060	
Critical Value 1% Level	3.78	

Across Ranch Analysis Standardized Results

To determine which trait explains the most variation in price (importance), the variables are standardized. Standardization was completed within each purebred ranch's data. After standardizing the variables the absolute value of the parameter is the importance of the variable in explaining price. These absolute values can then be ranked from highest to the lowest. The highest value indicates the trait that explains the most variation in price. Once again two separate regressions were completed in accordance with the gain traits. Table 7 included the birth to yearling gain variable. Table 8 includes pre- and post-weaning gain variables.

Table 7. Across Ranch Analysis Standardized—BYGEPD.

Variable	Ranch 1 Coefficient (t-value)	Ranch 2 Coefficient (t-value)	Ranch 3 Coefficient (t-value)	Ranch 4 Coefficient (t-value)	Ranch 5 Coefficient (t-value)
Birth EPD	-0.161	-0.147	-0.146	-0.198	-0.114
	(5.13)**	(2.88)**	(5.41)**	(4.04)**	(3.26)**
Gain EPD (BYGPD)	0.089	0.209	0.301	0.324	0.233
	(2.75)**	(3.76)**	(11.06)**	(6.42)**	(6.49)**
Intramuscular Fat	0.228	0.13	0.052	0.038	0.168
	(7.11)**	(2.08)*	(1.94)	(0.76)	(3.79)**
Rib-eye-area	0.185	0.28	0.158	0.226	0.187
	(5.47)**	(6.65)**	(6.39)**	(4.60)**	(5.23)**
Age	-0.025	1.08	0.012	0.111	0.092
	(0.83)	(5.70)**	(0.31)	(2.11)*	(2.56)*
Log Lot Number	-0.584	-0.147	-0.441	-0.26	-0.117
	(17.44)**	(2.93)**	(12.36)**	(4.88)**	(2.68)**
Year Dummy 05	9.448	-1.01	-0.909	-0.985	-0.558
	(4.84)**	(2.97)**	(2.70)**	(2.89)**	(3.19)**
Year Dummy 06	-1.439	-0.548	-1.21	-1.23	-0.563
	(4.28)**	(1.57)	(3.58)**	(3.62)**	(3.22)**
Hip Height	-0.197				
	(5.25)**				
Red Angus Dummy		0.443			
		(3.99)**			
Ranch 3 Dummy			-0.143		
			(2.70)**		
% Not Angus					1.112
					(3.33)**
Observations	3063				
R-squared	0.38				

Absolute value of t statistics in parenthesis
* significant at 5%; ** significant at 1%

For a one standard deviation increase in BEPD, the parameter estimate decreases approximately 0.15 standard deviations. BYGEPD had a range of standard deviation changes of price from 0.089 to 0.324. Pre-weaning gain had a range of 0.12 to 0.20, statistically significant for Ranches 2, 3, and 5. Ranches 1, 3, and 4 had significance for post-weaning gain with a range of 0.08 to 0.42. Intramuscular fat EPD ranged in standard deviation effects from 0 to 0.22 and REA had a range 0.15 to 0.28.

Table 8.Across Ranch Analysis Standardized—Pre (Post) Weaning Gain.

	Ranch 1	**Ranch 2**	**Ranch 3**	**Ranch 4**	**Ranch 5**
Variable	Coefficient (t-value)	Coefficient (t-value)	Coefficient (t-value)	Coefficient (t-value)	Coefficient (t-value)
Birth EPD	-0.164 (5.22)**	-0.144 (3.45)**	-0.142 (5.28)**	-0.191 (3.91)**	-0.124 (3.51)**
Gain EPD					
Pre-Weaning	0.088 (2.60)**	-0.067 (1.21)	0.227 (7.96)**	0.42 (7.90)**	0.065 (1.63)
Post-weaning	0.019 (0.62)	0.162 (3.27)**	0.129 (4.60)**	0.012 (0.24)	0.204 (5.12)**
Intramuscular Fat	0.235 (7.18)**	0.134 (2.64)**	0.059 (2.19)*	0.027 (0.54)	0.162 (3.65)**
Rib-eye-area	0.185 (5.52)**	0.28 (6.55)**	0.163 (6.59)**	0.194 (3.94)**	0.182 (5.09)**
Age	-0.025 (0.82)	1.04 (5.36)**	0.017 (0.43)	0.081 (1.53)	0.088 (2.45)*
Log Lot Number	-0.587 (17.56)**	-0.14 (3.37)**	-0.437 (12.30)**	-0.236 (4.42)**	-0.133 (2.99)**
Year Dummy 05	9.501 (4.89)**	-1.07 (3.05)**	-0.937 (2.80)**	-0.987 (2.91)**	-0.568 (3.27)**
Year Dummy 06	-1.464 (4.38)**	-0.571 (1.64)	-1.224 (3.64)**	-1.27 (3.75)**	-0.574 (3.29)**
Hip Height	-0.198 (5.31)**				
Red Angus Dummy		0.41 (3.57)**			
Ranch 3 Dummy			-0.141 (2.68)**		
% Not Angus					1.133 (3.41)**
Observations	3063				
R-squared	0.39				

Absolute value of t statistics in parenthesis
* significant at 5%; ** significant at 1%

Across Ranch Comparisons Standardized

F-tests were completed on each ranch to assure that the standardized parameters of the main traits of interest were not statistically the same. The null hypothesis is the parameters are equal. The test was whether the parameters associated with BEPD, BYGEPD, IMF and REA were equal for a ranch. The results reject the null, with F-stats greater than the critical value of 3.78, (1% level). The F-statistics are as follows: Ranch 1 was 80.36, Ranch 2 was 21.63, Ranch 3 was 21.31 and Ranch 4 was 17.74. The test was also completed on Ranch 5 with an F-statistic of 11.56. These results suggest that the variables have different importance or price explanatory power.

The variables are ranked by their ability to explain the variation price as indicated by the absolute value of the parameters. The variable with largest absolute value is responsible for explaining the most variation in price. The rankings are listed in Tables 9 and 10.

Table 9. Ranking of Traits—Birth to Yearling Gain.

	Ranch 1	**Ranch 2**	**Ranch 3**	**Ranch 4**	**Ranch 5**
Variable	Rank	Rank	Rank	Rank	Rank
Birth-weight	3	4	3	3	4
Birth to Yearling	4	2	1	1	1
Intramuscular Fat	1	3	-	-	3
Rib-eye-area	2	1	2	2	2

Table 10. Ranking of Traits—Pre (Post) Weaning Gain.

	Ranch 1	**Ranch 2**	**Ranch3**	**Ranch 4**	**Ranch 5**
Variable	Rank	Rank	Rank	Rank	Rank
Birth-weight	3	3	3	3	4
Pre-Weaning Gain	4	-	1	1	-
Post-weaning Gain	-	2	4	-	1
Intramuscular Fat	1	4	5	-	3
Rib-eye-area	2	1	2	2	2

Ranches leading genetic progress will be more likely to focus on carcass quality traits, because the emphasis on carcass quality is recent. Furthermore, the genetic leaders have already made progress in other traits. Ranch 1 is expected to be the leader in genetic improvements for Black Angus, and Ranch 2 is expected to be a leader in the Red Angus breed. The data supports that these two Ranches may be leading genetic improvements as bull buyers value IMF and REA more than BEPD or the gain variables. As can be seen in Tables 9 and 10 IMF and REA rank first and second for the traits bull buyers place the most emphasis for Ranch 1. Ranch 1 and Ranch 2 also indicate through discussion that they are trying to increase the carcass quality of their bulls.

The results from Ranch 3 and Ranch 4 indicate that their buyers value gain (BYGEPD) more than the other traits. Specifically their buyers value pre-weaning gain more than the other traits of interest. These two ranches both expressed that they are breeding for gain, because gain is their buyers' main selection trait. Ranch 3 and Ranch 4 also indicate they have placed less emphasis on breeding for carcass quality. The results from Ranch 5 are supportive of their market. Buyers of cross-bred bulls are selecting based on gain.

These results indicate that the buyers of bulls are informed about the different breeding programs of seed stock producers. The breeding programs of each individual ranch can be identified through the ranking of the traits.

F-tests were also completed on the standardized coefficients, Table 11, to evaluate if bull buyers place emphasis on traits differently across the ranches. The results indicate across the purebred ranches buyers of bulls place the same emphasis on certain traits.

Table 11. F-Tests on Standardized Regression Coefficients.

	Purebred Producers	
Variables	F-Stat	(P Value)
Birth-weight	0.34	(0.7963)
Birth to Yearling Gain	9.88	(0.000)
Pre-Weaning Gain EPD	11.43	(0.0000)
Post-Weaning Gain EPD	3.83	(0.0094)
Intramuscular Fat	6.90	(0.0001)
Rib-eye-area	2.32	(0.0730)
Number of Restrictions	3	
Degrees of Freedom	3060	
Critical Value 1% Level	3.78	

The p-value of 0.80 indicates that we fail to reject the null hypothesis of the standardized BEPD parameters being the same across the sales. Accounting for spatial aspects, buyers of bulls place the same importance on BEPD across the purebred ranches.

The test for emphasis of gain parameters across the ranches rejects the null. This provides evidence that producers purchase bulls based on gain for different production strategies. Producers also place different importance on intramuscular fat across the purebred ranches. The REAEPD, however, is only significantly different across the purebred ranches at the 10% level. These traits are linked to increase higher quality uniformity. Accounting for spatial aspects the buyers of bulls have individual selective breeding practices.

Summary

The results from the across ranch analysis support previous research that buyers of bulls use EPDs as selection tools. The results presented here have been corrected for multicollinearity between the gain traits. The buyers of bulls also value the information provided by carcass quality EPDs. Buyers' marginal value of the traits is different across the four purebred ranches. They also place different emphasis on the traits across the purebred breeders. Buyers of bulls are aware of individual purebred breeding programs and purchase bulls from ranches which best fit a cow-calf producer's selective breeding program.

CHAPTER 8

REGRESSION RESULTS: ANALYSIS THROUGH TIME

By completing a time analysis, it is expected that the marginal values as well as the standardized values will be statistically different, indicating an increasing or decreasing trend. The time analysis was completed on data from the sale years 2002 through 2006. Four regressions similar to the ones completed in Chapter 6 will be evaluated for Ranch 2 and Ranch 5. The difference between the analysis presented earlier across the ranches and the one in this chapter is that there is no year ranch dummy variable, only a year dummy variable to control for market factors specific to each year.[28] This chapter will first discuss the estimated parameters from Ranch 2 evaluated through time. These estimates will then be compared to the parameters estimates from Chapter 7. A similar analysis for Ranch 5 will follow, with the concluding section pertaining to trend and a comparison of Ranch 2 to Ranch 5 (purebred to cross-bred bull buyers).

Ranch 2 Regression Results, 2002-2006

The statistically significant parameter estimates are similar to the parameters attained through the across ranch analysis for Ranch 2. The results are in Tables 12 and 13.

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[28] Year specific marketing factors include inflation, cattle prices, feed prices etc.

Table 12. Ranch 2 Regression Results 2002-2006—BYGEPD.

Variable	**2002** Coefficient (t-value)	**2003** Coefficient (t-value)	**2004** Coefficient (t-value)	**2005** Coefficient (t-value)	**2006** Coefficient (t-value)
Birth EPD	-41.892	-81.92	-0.868	-66.48	-140.514
	[1.09]	[2.30]*	[0.02]	[1.40]	[2.19]*
Gain EPDs					
BYGEPD	31.731	14.781	13.896	22.373	29.429
	[6.15]**	[2.87]**	[2.43]*	[3.26]**	[3.81]**
Intramuscular	1,574.61	113.66	1,160.82	909.869	990.059
	[4.16]**	[0.32]	[2.96]**	[1.60]	[1.84]
Rib-eye-area	1,036.05	953.478	898.648	1,399.92	1,398.97
	[3.74]**	[3.53]**	[2.85]**	[3.45]**	[3.09]**
Age	4.682	4.842	8.844	2.71	18.21
	[3.45]**	[3.46]**	[2.61]**	[0.73]	[3.96]**
Log Lot Number	-1,223.66	-910.666	-369.656	-91.714	-497.426
	[15.16]**	[10.60]**	[3.60]**	[0.86]	[2.18]*
Red Angus	-1,525.00	-985.105	611.762	610.442	66.962
	[8.48]**	[4.90]**	[2.60]**	[2.56]*	[0.17]
Year Dummy	5,471.45	4,150.95	-1,319.47	-520.545	-4,711.57
	[5.77]**	[4.48]**	[0.82]	[0.31]	[1.65]
Observations	1763				
R-squared	0.41				

Absolute value of t statistics in brackets
* significant at 5%; ** significant at 1%

Table 13.Ranch 2 Regression Results 2002-2006 —Pre (Post) Weaning.

	2002	**2003**	**2004**	**2005**	**2006**
Variable	Coefficient (t-value)	Coefficient (t-value)	Coefficient (t-value)	Coefficient (t-value)	Coefficient (t-value)
Birth EPD	-39.216	-81.625	2.271	-66.254	-159.063
	[1.01]	[2.29]*	[0.04]	[1.39]	[2.45]*
Gain EPDs Pre-Weaning	36.597	17.863	19.278	24.31	-0.221
	[3.54]**	[1.74]	[1.55]	[1.51]	[0.01]
Post-Weaning	27.468	12.598	9.814	21.167	54.498
	[2.92]**	[1.55]	[0.97]	[1.86]	[3.61]**
Intramuscular Fat	1,583.04	115.935	1,190.96	912.715	1,009.60
	[4.18]**	[0.32]	[3.00]**	[1.60]	[1.87]
Rib-eye-area	1,065.01	965.103	885.914	1,398.44	1,179.65
	[3.77]**	[3.54]**	[2.80]**	[3.45]**	[2.53]*
Age	4.846	4.85	8.834	2.8	16.724
	[3.48]**	[3.46]**	[2.61]**	[0.74]	[3.59]**
Log Lot Number	-1,223.88	-906.139	-363.245	-93.514	-529.711
	[15.16]**	[10.43]**	[3.51]**	[0.87]	[2.32]*
Red Angus Dummy	-1,509.27	-965.822	625.195	624.767	-36.339
	[8.29]**	[4.63]**	[2.64]**	[2.39]*	[0.09]
Year Dummy	5,354.52	4,069.13	-1,410.05	-582.434	-3,622.98
	[5.51]**	[4.26]**	[0.87]	[0.33]	[1.24]
Observations	1763				
R-squared	0.41				

Absolute value of t statistics in brackets
* significant at 5%; ** significant at 1%

The estimated parameter for BEPD is significant for the years 2003 and 2006 and ranges from -81 to -159. Pre-weaning gain is only significant in year 2002 with the estimate of 36. Post-weaning gain has a range of parameter estimate from 27 to 54 in 2002 and 2006. Intramuscular fat has an estimated parameter for 2002 and 2004 ranging from 1200 to 1600. Rib-eye-area and BYGEPD are the only traits statistically significant across all five years. REA has a range of 900 to 1,400 and BYGEPD has a range of 14 to 30.

Ranch 2 Comparison: 2005- 2006 to 2002-2006 Regressions

The parameter estimates from the across-ranch analysis Chapter 7 should be a weighted average of the parameter estimates from the corresponding time analysis (individual years). For example, the 2005 BEPD parameter for Ranch 2 is zero and the 2006 parameter is -140 (Table 12). The parameter estimate for the years combined (Table 4) is -110. The value from the combined years is between the estimated parameters for the individual years. However, this is not true for BYGEPD, REA, and IMF.

If the regression contained a single independent variable the parameter estimates from (Tables 4 and 5) are expected to be between the 2005 and 2006 estimates from (Tables 12 and 13). This is true for the parameters of age, pre- and post-weaning gain and the Red Angus dummy variable. This is not true for BYGEPD, IMF or REA. The parameter estimated from Table 4 and Table 5 is outside the range of Tables 12 and 13.

In the simple one variable case Y_c is the endogenous variable and X_c is the exogenous variable for the combined years of 2005 and 2006, and alpha (α) is the intercept, ($Y_c = \alpha + \beta_c * X_c$) the parameter estimate is then β_c. This parameter β_c should be equal to the weighted average of the individual year parameters β_{05}, and β_{06} estimated from $y_{year} = \alpha + \beta_{year} * x_c$, where y and x are the variables from the specific year. From the following derivation:

(18) $$\beta_c = \beta_{05} * w_{05} + \beta_{06} * w_{06}$$

Betas (β) represent the parameter estimate and w represents the weights from each year. Equation (19) estimates β_c, the parameter for the years combined.

(19) $$\beta_c = \frac{\sum X_c * Y_c}{\sum X_c^2}$$

Using equations (20) and (21) the estimates of β for 2005 and 2006 are:

(20) $$\beta_{05} = \frac{\sum x_{05} * y_{05}}{\sum x_{05}^2}$$

(21) $$\beta_{06} = \frac{\sum x_{06} * y_{06}}{\sum x_{06}^2}$$

By substituting equations (20) and (21) into equation (19) it becomes:

(22) $$\beta_c = \frac{\sum x_{05} * y_{05} + \sum x_{06} * y_{06}}{\sum x_{05}^2 + \sum x_{06}^2}$$

Rearranging equations (20) and (21):

(23) $$\beta_{year} * \sum x_{year}^2 = \sum x_{year} * y_{year}$$

Substituting equation (23) into (22) for the respective year results in:

(24) $$\beta_c = \frac{\beta_{05} * \sum x_{05}^2 + \beta_{06} * \sum x_{06}^2}{\sum x_{05}^2 + \sum x_{06}^2}$$

By factoring equation (24):

(25)

$$\beta_c = \beta_{05} * \frac{\sum x_{05}^2}{\sum x_{05}^2 + \sum x_{06}^2} + \beta_{06} * \frac{\sum x_{06}^2}{\sum x_{05}^2 + \sum x_{06}^2}$$

(26)

$$w_{year} = \frac{\sum x_{year}^2}{\sum x_{05}^2 + \sum x_{06}^2}$$

Equation (26) then represents the weight (w_{year}) for each year. Equation (25) is then equal to equation (18).

(27)

$$\beta_c = \beta_{05} * \frac{\sum x_{05}^2}{\sum x_{05}^2 + \sum x_{06}^2} + \beta_{06} * \frac{\sum x_{06}^2}{\sum x_{05}^2 + \sum x_{06}^2} = \beta_{05} * w_{05} + \beta_{06} * w_{06}$$

The weights w_{05}, and w_{06}, must sum to one, $w_{05} + w_{06} = 1$. With this being the case in a simple one variable regression framework the combined parameters must be the weighted average of and between parameters from the individual year analysis.

However, the regression equations used in this thesis contain multiple right hand side variables. Multiple variable regression estimates of β_c do not have to be between the individual years estimated if the right hand side variables are correlated. If only gain, IMF or REA is included in the Ranch 2 regressions, the parameter for the combined years is between the estimated parameter for 2005 and 2006 in Table 12. Adding age as a regression variable causes the gain, IMF, or REA combined year parameter to move outside the individual year estimates. The collinearity between age and gain and age and IMF or REA is evidently causing incongruity between the combined and individual parameter year estimates.

Ranch 5 Regression Results 2002—2006

The parameter estimates for Ranch 5 were similar to the across ranch analysis as well. These results are in Table 14 and 15. The BEPD parameter had a range from 70 to 125 for 2002, 2003, and 2006. The total gain of the animal BYGEPD ranged from 17 to 25 over the five year period. The pre-weaning gain was valued by bull buyers in 2002, 2003, and 2006 with estimates from 23 to 40. Post-weaning gain was statistically significant for all years except for 2006 with parameter estimates of 16 to 40. Intramuscular fat was only significant in 2006 with a value of 2,093. The parameter estimates for REA were from 670 to 1,730 for the years 200, 2003, 2004 and 2006.

Ranch 2 and Ranch 5, 2002—2006
Standardized Regressions

The purpose of standardizing the variables was to determine which trait most explained prices. The variable that contained the most explanatory power as to the variation in price was then ranked as the most important variable to buyers bulls. Because the statistical significance of traits through the years was not consistant, the standardized results do not add any relative information to the research and will not be discussed.

Table 14. Ranch 5 Regression Results 2002-2006 —BYGEPD.

Variable	2002 Coefficient (t-value)	2003 Coefficient (t-value)	2004 Coefficient (t-value)	2005 Coefficient (t-value)	2006 Coefficient (t-value)
Birth EPD	-125.344	-148.646	-42.923	-72.17	-69.652
	[5.23]**	[6.07]**	[0.88]	[1.84]	[1.99]*
Gain EPDs					
BYGEPD	19.979	20.24	20.518	17.188	25.558
	[5.84]**	[5.44]**	[3.43]**	[3.34]**	[4.82]**
Intramuscular	95.264	331.199	515.303	400.543	2,093.01
	[0.34]	[1.22]	[1.02]	[1.04]	[4.21]**
Rib-eye-area	701.149	676.308	905.614	571.175	1,687.66
	[3.69]**	[3.21]**	[2.73]**	[1.72]	[5.22]**
Age	6.105	1.502	-2.014	-1.334	18.444
	[3.01]**	[1.53]	[0.50]	[1.48]	[5.33]**
Log Lot	27.246	56.085	10.407	-176.098	-164.37
	[0.70]	[1.30]	[0.11]	[2.43]*	[2.19]*
% Not Angus	66.36	-693.242	281.924	232.076	2,871.35
	[0.26]	[2.36]*	[0.55]	[0.48]	[5.20]**
Year Dummy	-4,221.89	-3,356.39	-1,360.78	44.91	-7,047.08
	[3.20]**	[3.17]**	[0.69]	[0.04]	[3.99]**
Observations	1814				
R-squared	0.33				

Absolute value of t statistics in brackets
* significant at 5%; ** significant at 1%

Table 15. Ranch 5 Regression Results—Pre (Post) Weaning.

	2002	2003	2004	2005	2006
Variable	Coefficient (t-value)	Coefficient (t-value)	Coefficient (t-value)	Coefficient (t-value)	Coefficient (t-value)
Birth EPD	-125.28	-148.264	-47.242	-88.595	-57.221
	[5.24]**	[6.07]**	[0.97]	[2.25]*	[1.60]
Gain EPDs Pre-Weaning	25.198	23.454	10.682	-8.709	41.659
	[3.41]**	[3.33]**	[1.01]	[0.84]	[3.74]**
Post-Weaning	16.395	17.421	30.609	37.402	13.505
	[2.90]**	[2.71]**	[2.85]**	[4.28]**	[1.49]
Intramuscular Fat	102.017	353.425	580.085	247.117	2,076.86
	[0.37]	[1.29]	[1.15]	[0.64]	[4.19]**
Rib-eye-area	710.456	671.11	818.699	445.728	1,729.28
	[3.74]**	[3.19]**	[2.41]*	[1.34]	[5.35]**
Age	6.223	1.521	-3.252	-1.295	19.383
	[3.07]**	[1.55]	[0.79]	[1.44]	[5.54]**
Log Lot Number	23.298	55.242	29.063	-199.876	-143.853
	[0.59]	[1.28]	[0.30]	[2.75]**	[1.89]
% Not Angus	76.571	-702.808	269.27	287.405	2,836.99
	[0.30]	[2.39]*	[0.53]	[0.59]	[5.15]**
Year Dummy	-4,327.91	-3,398.69	-890.854	587.483	-7,800.56
	[3.27]**	[3.21]**	[0.44]	[0.54]	[4.30]**
Observations	1814				
R-squared	0.33				

Absolute value of t statistics in brackets
* significant at 5%; ** significant at 1%

Analysis of Trend

Differences in level and standardized parameters over time may exist. As cattle producer react to market conditions they will be willing to pay more (less) for certain traits. The importance of the traits would also be linked to market conditions and the expectations formed by the buyers of bulls. Even though some traits are significantly different over time none of the traits exhibited an upward or downward trend.

Differences between Purebred and Cross-Bred Bull Buyers

The final test in this analysis was the comparison of purebred bull buyers to those of cross-bred bulls. There are no recognizable trends over time; the data was pooled over the 2005 and 2006 production years. Ranch 2 and Ranch 5 sell bulls at the same sale and therefore, the trait values can be compared without concern for spatial differences. F-tests were used to test whether trait values were different for the sale years 2005 and 2006 for Ranch 2 and Ranch 5.

The F-tests were completed on both non-standardized and standardized parameters. The results are in Table 16. The results from this analysis fail to reject the nulls that the traits are equal. The results suggest that buyers of bulls place the same marginal value on traits whether purchasing purebred or cross-bred bulls. The results also indicate that the importance of traits in explaining bull prices is not different between purebred and cross-bred bulls.

Table 16. F-Test for Time Analysis.

	Comparison Between Ranch 2 and Ranch 5	
	Non-Standardized	Standardized
Variables	F-Stat (P Value)	F-Stat (P Value)
Birth-weight	0.55 (0.4597)	0.26 (0.6087)
Birth to Yearling Gain	0.09 (0.7639)	0.15 (0.6963)
Pre-Weaning Gain EPD	0.01 (0.9151)	0.00 (0.9660)
Post-weaning Gain EPD	0.13 (0.7215)	0.47 (0.5152)
Intramuscular Fat	0.28 (0.5941)	0.21 (0.6507)
Rib-eye-area	0.95 (0.3301)	2.99 (0.084)
Number of Restrictions	1	1
Degrees of Freedom	3023	3023
Critical Values 1% Level	3.32	3.32

Summary

Analyzing the traits through time provided insight into possible market changes. The results from this analysis, however, do not reveal any increasing or decreasing trend in the value of traits. There are indications that cow-calf producers have valued traits differently over the five year period. With no apparent trend ,the results in this chapter provide support for combining the years 2005 and 2006 as was completed in Chapter 7. An analysis between the buyers of purebred and cross-bred bulls was completed, revealing these separate groups of buyers value the traits of bulls similarly.

CHAPTER 9

CONCLUSION

Consumers demand high quality beef, and an accurate measurement of beef quality is only achievable after the animal is slaughtered. However, breeding cattle or bulls are selected prior to the slaughter of their progeny. Because it is difficult to determine the quality of beef at production levels prior to slaughter, it is also difficult to determine the value of a high quality carcass trait. Part of the improvement in carcass quality is made through selective breeding for carcass genetics. This action takes place at the farm level when seed stock bulls are purchased, and the results are not realized until the consumer the puts the steak on their plate. It remains unclear just how cow-calf producers value the ability to increase carcass quality. This thesis has estimated the value of carcass quality EPD through the selective breeding practices of cow-calf producer.

Contributions to the Cattle Industry

Sellers of seed stock bulls provide EPDs at bull sales to assist buyers in assessing the future performance of bulls. The buyers use EPDs for selecting bulls on genetic merit to decrease the risk of low carcass quality and increase profits. Through a hedonic model the price of a bull is a function of the traits possessed. After evaluating individual regression results for each ranch (Chapter 7), this thesis confirms similar research by Dhuyvetter (1996), Chvosta (2001), Walburger (2002), and Turner (2004) that birth EPDs and weight gain EPDs influence bull prices. Furthermore, this thesis found that carcass quality EPDs exhibit a statistical significant influence on bull prices in most cases.

Carcass quality was measured by IMF and REA. These two variables directly affect consumer demand. Since a breeding bull's price is influenced by these carcass traits, consumer preferences (primary demand) must be (at least to some degree) transferred from the consumer through the marketing chain to bull buyers (derived demand). As expressed in Chapter 3, if the information is not being transmitted through all market levels, then the parameter estimates for carcass quality would be zero.

The purebred breeders in this study sell bulls nationally. There are spatial differences in sale location leading to the attraction of different buyers. This creates spatial differences among the buyers. The regression results reveal that the marginal value of traits is different between groups of bull buyers. Bull buyers also place different emphasis on traits except for BEPD. BEPD is directly related to potential calving problems. Cow-calf producers, no matter the location, are facing increasing labor cost. These increased costs affect the profits, and producers are opting to decrease potential problems at birth. The value of traits for the buyers of cross-bred bulls is similar to the buyers of purebred bulls.

No intertemporal trends in the value of EPDs from 2002 to 2006 could be identified. It is apparent gain and carcass traits have been valued through time. Without trend this thesis was unable to determine when carcass traits were accepted by cow-calf producers as reliable selection tools. Based on the results from Chapter 8, buyers of bulls must have accepted carcass EPDs prior to 2002.

Controlling for the multicollinearity of the gain traits contributed to this analysis in two ways. The first way was the potential elimination of estimation problems. The second way was that controlling for multicollinearity provided reference as to how producers value different stages of gain. The results make it apparent that cow-calf producers selectively breed for gain depending on their profit maximization strategy, making different selections based on pre (post)-weaning and total gain.

Further Research

The results of this research indicate information is being transferred between levels in the beef market. Even so the degree of transfer or the specific channels have not been indentified. By discovering these channels, the costs associated with information transfer can then be evaluated more extensively and time lags determined. The efficiency of the market depends on how and when the cow-calf producer reacts to market changes.

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