

**HEDONIC BULL PRICING MODELS:  
ESTIMATING THE VALUE OF TRAITS OF  
BULLS SOLD FOLLOWING PERFORMANCE  
TESTING**

by

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## ABSTRACT

Selection of a herd sire has always been of paramount importance given the initial financial investment and their contribution and effect on the genetic make-up of a beef herd. Data was collected from the nation's longest consecutively run bull test conducted at the University Farm of Oklahoma Panhandle State University (OPSU). The Bull Test and Bull Sale data utilized were collected from 2008-2013. Performance data was collected over a 112 day test period with data collection occurring at 28 day intervals. The top seventy bulls from each year's test were selected based upon a performance index of  $\frac{1}{2}$  ADG and  $\frac{1}{2}$  weight per day of age (WDA), and a semen quality and motility score of excellent and sold at auction. Angus bulls were the focus of the study as they represented the vast majority of individuals sold. Three hedonic pricing models were created to try to determine what attributes buyers at the OPSU bull test sale were placing emphasis on. The initial hedonic model contained production data that included BW, ADG, WDA, Julian age, final test weight ultrasound data, and a dummy variable for sale year. The second model utilized all production data and added genetic variables in the form of production EPDs (Calving Ease Direct (CED), BW, Weaning Weight and Yearling Weight) and maternal EPDs (Calving Ease Maternal, Maternal Milk). The third model included the variables from the first and second models with the inclusion of carcass EPDs (Marbling, Ribeye Area (REA) and FAT). Year was significant in all three models however there was less of an effect on price as more variables were included. In model one, the production facts that were of significance were: ADG ( $P < 0.01$ ), BW ( $P < 0.01$ ) and final test weight ( $P < 0.01$ ). In the second model, ADG, BW and final test weight retained their significance

at the  $P < 0.01$  level. The only production EPD that was significant ( $P < 0.05$ ) was CED. In the third model, years, ADG and BW were still significant ( $P < 0.01$ ). Final test weight ( $P = 0.70$ ) and CED ( $P = 0.132$ ) had substantial changes. The carcass EPD ribeye area had a P value of 0.057. Producers who are placing bulls on test can utilize the given information to assist with their selection. It cannot go unsaid that while single trait selection can be very detrimental; ADG was significant across all models. The study indicates that performance and growth are of utmost importance to buyers, followed by birth weight consideration.

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## **CHAPTER I: INTRODUCTION**

Proper sire selection is a cornerstone in maintaining and building upon a beef herd's genetic profile. Males contribute the majority of the overall genetic make-up of a herd by having the opportunity to sire multiple offspring in a natural mating situation and through the use of artificial insemination; sires can be introduced to diversify the genetics in a herd. A producer may change his genetics by either purchasing new females or by introducing new sires. With the introduction of new females the impact in the herd's genetic makeup is minimal especially if she is a raised replacement being re-introduced into the herd. As Dr. Dan Moser states in the Beef Sire Selection Manual (Moser 2010), "Genetic change is a permanent change. Among management decisions, genetic selection differs from others in that effects are not temporary."

In addition to a producer's personal desire to increase the genetic merit of his/her beef herd the market provides opportunities to reward those producers that have taken the time and initiative to select genetics that will result in calves that the market desires. In a time when commodity cattle were the norm there was little incentive other than personal to work towards improving the final rail merit of their cattle. The traits that were most desirable were growth related as conversion was king, getting the cattle through the yard in the shortest amount of time possible was the incentive to improve cattle. While today we still are selecting for those types of cattle that can go to the bunk and convert efficiently, we now have other incentives that are important. This is evidenced through the decline in cattle marketed using the live pricing method where a single price is applied to all the cattle



sold in the lot. The trend today is toward cattle being marketed by using a formula to price the cattle, a forward contract or a value based marketing arrangement that arrives at a final carcass price for each individual based on the merits of the carcass. Additionally, the proliferation of branded beef lines in recent years has given producers incentives to raise a type and kind of cattle that can capitalize on these marketing methods. As these traits are those that can be measured through ultrasound and most accurately after the point of harvesting, using the EPD's that individual breeds have developed are a way for producers to make decisions regarding their sire purchases.

During the past two years producers in the High Plains have suffered from extreme drought conditions. During this time there has been an exodus of cows from the area. As such the majority of cow/calf producers serviced by the Oklahoma Panhandle State University (OPSU) Bull Sale have been forced to cull their respective herds. This has led to a majority of producers having decreased numbers and relatively young herds. Those females that remained in the herd were either those deemed to have exceptional genetic merit or were kept due to the fact that they were young and will have more longevity when drought conditions have weakened. We are entering a period where the droughts effects have lessened and the potential for herd rebuilding exists. With the rebuilding of the herds comes an increased demand for herd sires. As OPSU primarily sells bulls from our registered Angus herd evaluating what properties producers place value upon is important.

Through the use of hedonic pricing models and regression analysis the value placed upon the traits by buyers can be discovered. As producers we can utilize this knowledge to direct our breeding efforts and to attempt to maximize the revenue generated by our sale offerings. Additionally, through the efforts of breed associations the amount of genetic

information in the form of EPD's is tremendous and again using a hedonic model and regression analysis we can perhaps gain insight to which values in a bull's genetic profile producers are placing value.

## **CHAPTER II: LITERATURE REVIEW**

The decision to purchase and introduce a new sire into a beef herd is a complex decision for a producer. The choice is not as simple as comparing the purchase cost between bulls within a breed. A producer should identify needs within their herd that can be addressed through the introduction of a new sire. The new sire's genetic contribution to the overall genetic make-up of a beef cattle herd can assist in affecting those changes. This is accomplished through the bull contributing 50% of the genetics of each calf he sires and over time leading to a 90% change in the genetic change in a beef herd (White 1991). Additionally, given the variation in heritability of different traits the process of improving a beef herd through selective breeding will require an investment of time.

Initially, producers attempting to influence the improvement of their herds based their decisions on visual appraisal of the phenotypic attributes of a sire. These traits were things such as: structural correctness, volume, degree of muscularity, frame size and apparent weight. These are still used in selection criteria of modern producers. A system to express the prediction of the performance of future offspring from a sire has been developed over time and are referred to as Expected Progeny Differences (EPDs). These predictive values have increased in number and accuracy as technology has allowed producers to capture and analyze more data from calves sired by individual bulls. Additionally, the EPD offerings have expanded in number to reflect traits that producers are wanting to use in their selection criteria. An example would be as beef producers have moved away from producing simple commodity beef and are attempting to capture the benefit of improving the merits of their cattle through the use of value based marketing methods, EPDs were developed to reflect things such as marbling, ribeye size and the amount of external fat located at the 12<sup>th</sup> rib. Most recently with a period of increased feed

costs and drought, the ability of offspring to utilize forage and feeds has led to the development of efficiency measures such as: residual average daily gain and cow energy value.

Modern producers have the potential to utilize both traditional phenotypical evaluation and combine this with evaluating a sire's genetic profile in making their purchasing decision. As herd sire selection is the purchase of a capital asset and reflects an investment into the beef herd, previous work has been done in explaining what producers are placing emphasis on while making their decisions. The current producer has the potential to receive a large amount of information about individual potential sires.

As the purchase of a herd sire is an investment, Clary, Jordan and Thompson (1984) utilized net present value analysis to discover the marginal bid price for a sire. Their research evaluated the after tax cash flows associated with the increased revenues associated with the increase in weaning weights of superior sires. Additionally, the study analyzed the effects of varying tax rates, prices received for calves at sale, discount rates, time in the herd and financing arrangements. This analysis resulted in tables to express what a producer could pay above the value of the current herd sire. They determined that as the marginal tax rate increased the marginal bid decreased. A producer utilizing financing could increase their marginal bid for sires as they utilized more financing from an external source. The marginal bid would decrease as the marginal tax rate increased as the benefits of ownership (deductions to a producer's tax liability) did not increase as tax rates increased. Additionally, the marginal bid would increase significantly as the duration of the herd sires utilization in the herd increased.

A study by Dhuyvetter et al. (1996) used a hedonic model to investigate how EPDs influenced the final price paid for bulls. Data was collected from 26 purebred bull sales in Kansas in 1993. Producers were contacted for sale catalogs that contained physical and genetic information for bulls offered for sale. Data was analyzed using ordinary least squares regression. The model utilized was:

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

This study concluded that producers used phenotypic traits find bulls with superior conformation, muscling, and disposition. Additionally, a premium was paid for older bulls but this premium was not linear in nature as the amount of premium decreased as age increased.

The results in regards to the included EPDs was that the inclusion of EPDs was important in a buyers purchasing decision. There was differences within breeds as to which traits were statistically significant.

A study by Chvosta, Rucker and Watts (2001) continued the evaluation of the inclusion of EPDs in a producers buying decision. A hedonic model was used in the comparison of EPDs and simple performance measures (SPMs). The SPMs are: own birth weight, weaning weight and yearling weight and pedigree. The model from this study was:

$$\text{Bull Price} = f(\text{Beef Price, Feed Price, Age, Performance Measures})$$

Several models were estimated from the data; a model with both SPMs and EPDs, a model with SPMs only and a model with EPDs only. Chvosta et al. (2001) concluded that buyers placed significance in both SPMs and EPDs. Additionally, the model for SPMs had

more explanatory power within the herd. Chvosta et al (2001). concluded that the EPDs yield more explanatory power when comparing sires across herds.

As the EPDs for different attributes expanded Jones et al. (2008) conducted a study to re-examine the importance of EPDs in breeding bull purchases. An emphasis was placed on EPDs associated with carcass quality.

Data was collected from 60 sales from producers in the following regions: Midwest, Rocky Mountains and the Northwest. Within these regions 11 states reported sales information.

The study had two primary objectives: 1) re-examining the economic values of production EPDs and how they compare to the values assigned to actual weights, 2) assess the impact that ultrasound EPDs have on Angus bull prices.

The first objective yielded results that showed that on a relative scale, producers place more emphasis on birth EPD than on the actual physical measure. The same relationship was not true for the remaining EPDs which were associated with performance and carcass attributes.

In regards to the second objective, all four ultrasound EPDs were highly significant. Specifically the ultrasound EPD for ribeye had a larger response than birth EPD and adjusted yearling weight EPD. The significance would indicate that producers understand and place value on the ultrasound data related to ribeye size.

Jones et al. (2008) in addition to the two primary objectives examined other marketing factors that can influence the final price paid for Angus bulls. The pedigree of the potential sire was significant as well as the reputation of the individual breeder. Other

factors that had a positive influence on the price paid were: pictures, embryo transfers, retention of semen rights and bulls sold in the fall.

The authors also noted that two measures: physical appearance and structural correctness were not included in the study. The study noted that these attributes are often used by buyers in their ultimate buying decision and can be as important to buyers as EPDs and actual weights.

Recently Brimlow and Doyle (2014) used data from a Nevada bull test station using the years 2007, 2008, 2009 and 2012. The data for years 2010 and 2011 were not available. The authors addressed potential collinearity between birth, weaning and yearling EPDs by substituting a birth-to-yearling gain measure which they calculated by subtracting an individual bulls birth EPD from its yearling EPD. Additionally a trait associated with feed efficiency was included in the model in the form of residual feed intake.

The model yielded a high adjusted R-square value of 0.68 indicating the chosen variables were reasonably explanatory of the final model results.

Results for certain variables were similar to previous research such as the birthEPD received a higher premium than actual birth weight which Jones (2008) had the same result. The birth-to-yearling EPD had the highest coefficient indicating buyers were willing to pay for growth potential. Ultrasound measurements were favored versus their genetic counterparts.

While Jones et al. (2008) did not include conformation and structural correctness in the model used Brimlow and Doyle (2014) included a Total Conformation Score. While statistically significant it was calculated to have the lowest coefficient associated with it,

leading the authors to determine as an indication that buyers place less emphasis on seller provided summary scores than on phenotypic and genetic measures.

The residual feed intake was statistically significant indicating that producers in the Western United States placed value on the potential for a sire's offspring to be more efficient in converting feed to pounds of body weight.



### **CHAPTER III: THEORY**

Hedonic pricing is the theory that a good's value if it is not explicitly discovered is derived from the sum of each of the characteristics or values that comprise the good. These characteristics have an implicit value which equate to the price paid for the good. This modeling lends itself to discovering the value of the characteristics through the use of regression equations. Hedonic models have been developed for different stages along the beef supply chain (Parcell, et al. 2006) and for other species (Vickner and Koch 2001). A bull buyer can take cues from the premiums and discounts offered by the markets to weight the value of different characteristics associated with individual bulls. If there are premiums associated with grading in the upper two thirds choice quality grade, a producer may place value on the intramuscular fat epd, if the signal is that there are premiums in achieving lower numerical yield grades, there will be emphasis on values associated with muscle such as ribeye epd and buyers will potential discriminate against bulls with more condition at time of ultrasound. Ideally, producers will avoid single trait selection and will strive to select sires that have a balanced genetic profile but can still add value to their herds. The purpose of this project is to see to what extent the data provided to the potential buyers is utilized and within the data provided which attributes the buyers are placing the most emphasis when making their buying decision.

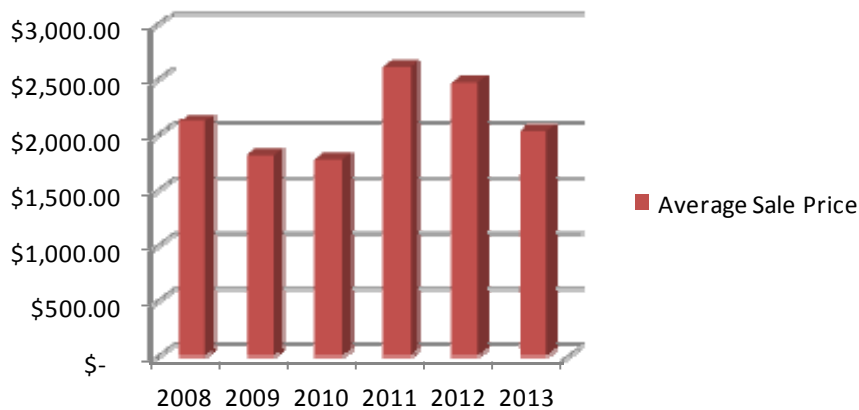
## **CHAPTER IV: DATA AND METHODS**

The data used was from the Oklahoma Panhandle State University Bull Test Sale from the years 2008-2013. Each year the nominated bulls arrive in mid-September and are then tagged, assigned a pen and go through a 21 day acclimation period before the test begins in early October. The test period is for 112 days during which time the bulls are weighed four times, 28 days apart. Upon the completion of the feeding test the bull's ultrasound measurements are taken for: rib fat, rump fat, ribeye area and marbling. Additionally, the 70 top ranking bulls undergo semen testing. The top 70 bulls are based on an index created from 50% average daily gain and 50% weight per day of age and if they are confirmed to have viable semen are sold approximately the third week of February.

On the day of the sale potential buyers are provided with a sheet with the data summarizing the performance of the individual during the course of the testing period and a sale catalog containing the EPDs associated with each bull. The data used for this project was obtained from the materials that were made available to the buyers on sale day.

Six years (2008-2013) data was entered which resulted in 420 individuals being in the initial data set. The breeds represented were: Angus, Simmental, Belgian Blue, Maine Anjou, Hereford and Santa Gertrudis. The sale averages (with no sales removed) varied from year to year with the lowest average price in 2010 at \$1,782.14 average per head and a high in \$2,468.93 average per head in 2011. A graph of the average sale price per year of the study is located in table 4.1.

**Figure 4.1 Average Bull Sale Price 2008-2013**



Breeds other than Angus over the six year period equaled 26 head total and as such will be dropped from the model before being run. Additionally not all of the Angus cattle auctioned resulted in a sale. These “no sales” will also be removed from the model as they do not represent a sale. In addition to the “no sales” not all of the Angus cattle sold through the sale have a complete genetic profile available in the sale catalog as they are missing some of their EPDs. A producer may be able to acquire this information from the Angus Association as all bulls sold through the OPSU sale are virgin bulls and as such only have interim epd values assigned to them but only information that was available on the day of the sale will be used for analysis.

#### **4.1 Data**

Data was entered into a spreadsheet from paper copies of materials that were available to producers on the day of sale for the various years. Six years’ worth of data was utilized (2008-2013) with a total number of 420 bulls initially entered. The information available to the purchasers from the feeding trial consisted of the following: The individual’s birth date, the individual’s actual birth weight (lbs), adjusted 205 day weight, adjusted 365 day weight for Junior Bulls, adjusted 452 day weight for Senior Bulls, final

test weight of the individuals (lbs), ADG for the test, ADG Index, WDA, WDA Index, adjusted 365 day rump fat (inches) from ultrasound, adjusted 365 day rib fat (inches) from ultrasound, adjusted 365 ribeye area (sq. inches) from ultrasound, adjusted 365 intramuscular fat (%) from ultrasound, scrotal circumference (cm) and adjusted 365 day frame score. In 2009 a hip height (inches) value was included but this was the only year it was included. The performance information was contained on a document that indicated sale order. EPD information was included in a sale catalog that was also available for producers. The sale catalog was ordered according to the Lot number that was assigned to the pen of cattle upon their arrival at the test facility.

The genetic information is in the form of expected progeny differences (EPDs). Through the years of data that was analyzed the EPD profile evolved to include new EPDs that were implemented by the American Angus Association. The development of new EPD values resulted in bulls being sold after 2009 having a greater number of available EPDs than in the two years prior. This discrepancy resulted in a section of EPDs being dropped from the models. Those EPDs were: Dollars weaning (\$W), Dollars Feedlot (\$F), Dollars Gain (\$G), Dollars Quality Grade (\$QG), Dollars Yield Grade (\$YG) and Dollars Beef (\$B). The EPDs that were consistently available across all years of the study were: Calving Ease Direct or Calving ease in some years (CED or CE), Birth Weight (BW), Weaning Weight (WW), Yearling Weight (YW), Yearling Height (YH), Scrotal Circumference (SC), Calving Ease Maternal or Maternal Calving Ease (CEM or MCE), Milk or Maternal Milk (MILK or MM), Mature Weight (MW), Mature Height (MH), Dollars Energy (\$EN), Carcass Weight (CW), Marbling (MARB), Ribeye Area (RE) and Fat (FAT).

Definitions of each independent variable along with their associated abbreviation and anticipated sign are following the description of the models.

#### **4.2 Model 1**

This model focused on values that were derived from the testing period. As stated earlier, 420 head comprised the initial group. Non-Angus breeds totaled 26 head and were removed from the data. Additionally within the remaining Angus bulls not all of the animals were successful sold through the auction. The consigner has the option to “no sale” individuals if they do not bring a minimum required bid. This resulted in 27 additional bulls being removed from the model as no sale price had been determined for that animal or lot. It was determined that an additional five bulls had no data for the actual birth weight of the individual and as such were dropped from the model. The total of observations that were removed was 58 head resulting in 362 individuals remaining to be analyzed with the initial model.

We constructed this model with the belief that as all the bulls had successfully completed the feeding trial, this data set would be the most complete and have a high number of observations to evaluate. Anecdotally, we believe that most individuals “buy with their eyes” and these traits that comprised the majority of the first model were those that could be visualized (size and weight). The variables included were either performance based (ADG, WDA) or of a physical nature (final test weight, birth weight) including ultrasound data for ribeye area. Additionally a binary dummy variable for each year (YR), 2008-2012 was included using 2013 as the benchmark to which all other years were compared. Additionally as no specific EPDs were included in the model a binary variable was included to represent if there were EPDs associated with the individual in the catalog.

*Empirical Model: (Equation 1 – production test)*

$$\text{Price} = \beta_0\text{INT} + \beta_1\text{Age} - \beta_2 \text{Agesq} - \beta_3\text{YR2008} - \beta_4\text{YR2009} - \beta_5\text{YR2010} - \beta_6\text{YR2011} - \beta_7\text{YR2012} + \beta_8\text{BirthWT} + \beta_9\text{TestWT} + \beta_{10}\text{ADG} + \beta_{11}\text{WDA} + \beta_{12}\text{Ribeye} + \beta_{13}\text{Scrotal} + \beta_{14}\text{Frame} + \beta_{15}\text{EPDinCat} + \varepsilon_t$$

Where:

Price = Price of Angus bulls sold at auction (\$/head)

INT = Intercept

Age = Age of the bull in days from birth to date of auction

Agesq = Age of bull in days from birth to date of auction squared

YR2008 = 1 if sale of bull occurred in 2008 and = 0 otherwise

YR2009 = 1 if sale of bull occurred in 2009 and = 0 otherwise

YR2010 = 1 if sale of bull occurred in 2010 and = 0 otherwise

YR2011 = 1 if sale of bull occurred in 2011 and = 0 otherwise

YR2012 = 1 if sale of bull occurred in 2012 and = 0 otherwise

BirthWT = Individual birth weight of bull in pounds

TestWT = Individual weight of bull at final weigh date of test (112 days) in pounds

ADG = Average daily gain associated with the individual for the test period

WDA = Weight gain per day of age (birth to completion of testing period) for the individual in pounds

Ribeye = Size of ribeye in square inches from ultrasound

Scrotal = Circumference of scrotum in centimeters

Frame = Frame Score associated with individual bull

$EPD_{inCat} = 1$  if the individual had EPDs shown in the sale catalog and  $= 0$  otherwise

*Price* = Price of Angus bulls at auction is determined by:

*Age* = It is hypothesized that the coefficient will be positive. As this is the age of the individual this can be an indicator of the growth of the individual if they appear to be at a higher weight than their contemporaries and their readiness to be utilized for breeding. Some buyers will be willing to pay more for a “Senior” bull that they believe is able to enter the herd and breed more females than a “Junior” bull potentially could.

*Agesq* = It is hypothesized that the coefficient will be negative. As was discussed when hypothesizing about the age coefficient there will be a point where buyers will be willing to pay less for each day of age. By the inclusion of the age squared coefficient the non-linear nature of this attribute should be discovered.

*YR2008* = It is hypothesized that the coefficient for bulls sold in 2008 to have positive sign. This is due to the fact that the sale average was higher in 2008 than 2013 which is the benchmark year.

*YR2009 – YR2010* = It is hypothesized that the coefficient will be negative as both years have sale averages less than the benchmark year 2013 sale average.

*YR2011 - YR2012* = It is hypothesized that the coefficient will be positive as both years have a sale average greater than the benchmark year of 2013 sale average.

*BirthWt* = it is hypothesized that the coefficient will be negative. This is the actual birth weight of the individual and is an indicator of the potential birth weight of his offspring. As the weight increases so does the potential for calving problems due to dystocia which could make buyers pay less for bulls with higher birth weights.

*TestWt* = It is hypothesized that the coefficient will be positive. Final test weight can be thought of as indicative of the growth potential of the individual. As most people equate weight in cattle with performance those individuals that are at a higher weight within their contemporary groups may be seen as more desirable.

*ADG* = It is hypothesized that the coefficient will be positive. This is the measurement of the average daily body weight change over the course of the testing period. The higher the ADG the more efficient the animal is at converting feed which would be of interest to producers as this could result in cost savings and more pounds of saleable calf from his offspring resulting in a potential increase to profitability.

*WDA* = It is hypothesized that the coefficient will be positive. An individual with a higher weight per day of age would be of value to a producer as a larger number speak to the growth ability of the animal. Producers could hypothesize that the higher WDA would result in more pounds of calf at marketing resulting in more revenue.

*Ribeye* = It is hypothesized that the coefficient will be positive. The ultra-sound data is of value as it is the best means of establishing a ribeye area for the individual while it is alive. As the ribeye area is an indicator of muscling, an increase in ribeye size would equate to more product of saleable red meat from sired offspring.

*Scrotal* = It is hypothesized that the coefficient will be positive. As this is related to age of puberty of females those producers that retain replacement females will place a premium on those individuals with larger scrotal circumferences. The ability of females to reach first estrus earlier can be bred quicker and can potentially maintain a shorter interval between calving and rebreeding. Those producers that have a terminal production system will more than likely be only concerned that scrotal development is such that viable semen



are produced in enough quantity so they can be confident in the individual's ability to breed.

*Frame* = We are unsure as to the sign of this coefficient. This is due to the fact that no frame size is considered perfect and is more to the producer's preference or type and kind of cattle.

*EPDinCat* = it is hypothesized that the coefficient will be positive. If the producer has more information on which to base their buying decision the greater the likelihood that there will be an increase in price.

#### **4.3 Model 2**

Using the belief that producers would place value on information that could indicate potential performance of future offspring model 2 includes production and maternal EPDs. The production EPDs that were included were: Calving Ease Direct (CEE<sub>PD</sub>), Birth Weight (BWE<sub>PD</sub>), Weaning Weight (WWE<sub>PD</sub>) and Yearling Weight (YWE<sub>PD</sub>). The maternal EPDs that were introduced into the second model were: Maternal Calving Ease (MCEE<sub>PD</sub>) and Maternal Milk (MME<sub>PD</sub>). As actual EPD values were now included in the model the binary dummy variable for EPDinCat was dropped from the model. Due to the incomplete nature of the EPD profiles of the data set the inclusion of the new independent variables resulted in a loss of observations. Of the 362 initial bulls; 72 head were not included in Model 2 resulting in a total of 290 bulls that were remaining to be analyzed with the second model.

**Empirical Model: (Equation 2 – production test + Performance EPDs and Maternal EPDs)**

$$\begin{aligned} \text{Price} = & \beta_0 \text{INT} + \beta_1 \text{Age} - \beta_2 \text{Agesq} - \beta_3 \text{YR2008} - \beta_4 \text{YR2009} - \beta_5 \text{YR2010} - \\ & \beta_6 \text{YR2011} - \beta_7 \text{YR2012} + \beta_8 \text{BirthWT} + \beta_9 \text{TestWT} + \beta_{10} \text{ADG} + \beta_{11} \text{WDA} + \beta_{12} \text{Ribeye} + \\ & \beta_{13} \text{Scrotal} + \beta_{14} \text{Frame} + \beta_{15} \text{CEE PD} - \beta_{16} \text{BWE PD} + \beta_{17} \text{WWE PD} + \beta_{18} \text{YWE PD} + \\ & \beta_{19} \text{MCEE PD} + \beta_{20} \text{MME PD} + \epsilon_t \end{aligned}$$

Where:

Price = Price of Angus bulls sold at auction (\$/head)

INT = Intercept

Age = Age of the bull in days from birth to date of auction

Agesq = Age of bull in days from birth to date of auction squared

YR2008 = 1 if sale of bull occurred in 2008 and = 0 otherwise

YR2009 = 1 if sale of bull occurred in 2009 and = 0 otherwise

YR2010 = 1 if sale of bull occurred in 2010 and = 0 otherwise

YR2011 = 1 if sale of bull occurred in 2011 and = 0 otherwise

YR2012 = 1 if sale of bull occurred in 2012 and = 0 otherwise

BirthWT = Individual birth weight of bull in pounds

TestWT = Individual weight of bull at final weigh date of test (112 days) in pounds

ADG = Average daily gain associated with the individual for the test period

WDA = Weight gain per day of age (birth to completion of testing period) for the individual in pounds

Ribeye = Size of ribeye in square inches from ultrasound

Scrotal = Circumference of scrotum in centimeters

Frame = Frame Score associated with individual bull

CEEPD = Angus Calving Ease Direct EPD

BWEPD = Angus Birth Weight EPD

WWEPD = Angus Weaning Weight EPD

YWEPD = Angus Yearling Weight EPD

MCEEPD = Angus Calving Ease Maternal EPD

MMEPD = Maternal Milk EPD

*Price* = Price of Angus bulls at auction is determined by:

*Age* = It is hypothesized that the coefficient will be positive. As this is the age of the individual this can be an indicator of the growth of the individual if they appear to be at a higher weight than their contemporaries and their readiness to be utilized for breeding. Some buyers will be willing to pay more for a “Senior” bull that they believe is able to enter the herd and breed more females than a “Junior” bull potentially could.

*Agesq* = It is hypothesized that the coefficient will be negative. As was discussed when hypothesizing about the age coefficient there will be a point where buyers will be willing to pay less for each day of age. By the inclusion of the age squared coefficient the non-linear nature of this attribute should be discovered.

*YR2008* = It is hypothesized that the coefficient for bulls sold in 2008 to have positive sign. This is due to the fact that the sale average was higher in 2008 than 2013 which is the benchmark year.

*YR2009 – YR2010* = It is hypothesized that the coefficient will be negative as both years have sale averages less than the benchmark year 2013 sale average.

*YR2011-YR2012* = It is hypothesized that the coefficient will be positive as both years have a sale average greater than the benchmark year of 2013 sale average.

*BirthWt* = it is hypothesized that the coefficient will be negative. This is the actual birth weight of the individual and is an indicator of the potential birth weight of his offspring. As the weight increases so does the potential for calving problems due to dystocia which could make buyers pay less for bulls with higher birth weights.

*TestWt* = It is hypothesized that the coefficient will be positive. Final test weight can be thought of as indicative of the growth potential of the individual. As most people equate weight in cattle with performance those individuals that are at a higher weight within their contemporary groups may be seen as more desirable.

*ADG* = It is hypothesized that the coefficient will be positive. This is the measurement of the average daily body weight change over the course of the testing period. The higher the ADG the more efficient the animal is at converting feed which would be of interest to producers as this could result in cost savings and more pounds of saleable calf from his offspring resulting in a potential increase to profitability.

*WDA* = It is hypothesized that the coefficient will be positive. An individual with a higher weight per day of age would be of value to a producer as a larger number speak to the growth ability of the animal. Producers could hypothesize that the higher WDA would result in more pounds of calf at marketing resulting in more revenue.

*Ribeye* = It is hypothesized that the coefficient will be positive. The ultra-sound data is of value as it is the best means of establishing a ribeye area for the individual while it is alive. As the ribeye area is an indicator of muscling, an increase in ribeye size would equate to more product of saleable red meat from sired offspring.

*Scrotal* = It is hypothesized that the coefficient will be positive. As this is related to age of puberty of females those producers that retain replacement females will place a premium on those individuals with larger scrotal circumferences. The ability of females to reach first estrus earlier can be bred quicker and can potentially maintain a shorter interval between calving and rebreeding. Those producers that have a terminal production system will more than likely be only concerned that scrotal development is such that viable semen are produced in enough quantity so they can be confident in the individual's ability to breed.

*Frame* = We are unsure as to the sign of this coefficient. This is due to the fact that no frame size is considered perfect and is more to the producer's preference or type and kind of cattle.

*CEEPD* = It is hypothesized that the coefficient will be positive. As this value is the indicative of the potential number of unassisted births associated first calf heifers when bred to the individual. The higher value would represent a labor savings to the producer and a greater likelihood of a producer getting a live calf.

*BWEPD* = It is hypothesized that the coefficient will be negative. As was discussed with the actual birth weight measurement of the individual, a higher value would mean that calves from mating to the sire could result in heavier weight calves. Heavier calves have more instances of complicated births which a producer will discriminate against. A lower *BWEPD* would be more desirable to producers.

*WWEPD* = It is hypothesized that the coefficient will be positive. Weaning Weight (WW) is the sire's effect on weight at time at weaning. A higher value when compared to a

contemporary would be indicative of more saleable pounds at weaning. This increase to growth is economically relevant to producers.

*YWEPD* = It is hypothesized that the coefficient will be positive. Yearling Weight (YW) is the sire's effect on weight yearling growth. A higher value when compared to a contemporary would be indicative of more saleable pounds as a yearling. This increase in growth is economically relevant to producers.

*MCEEPD* = It is hypothesized that the coefficient will be positive. Maternal calving ease is an indicator of the ease of calving for first calf heifers that have been sired by the individual. This would be of mixed value, depending on the mix of buyers at the auction. Those individuals that operate terminal operations will likely not place much emphasis on this EPD when making their selection. However, those that purchase bulls and retain replacement heifers will place emphasis as the higher the value the less instance of troubled calving should be associated with the female. As was discussed with the calving ease associated with breeding directly to the potential sire, an easy birth saves a producer time, labor and expense.

*MMEPD* = We are unsure as to the sign associated with this coefficient. The maternal milk epd is the portion of a calf's weaning weight that can be associated with the female. A higher value would indicate a heavier milking female, which can be good or bad. A higher milking female will have higher feed requirements to maintain her condition and provide for the calf. In areas with marginal available feed and those areas affected by drought, this increase in feed requirement could result in increased cost for the producer.

#### **4.4 Model 3**

The third and final model consists of Model 2 with the inclusion of the carcass EPDs for Marbling (MARBEPD), Ribeye Area (REEPD), and Carcass Fat (FatEPD). The

inclusion of the carcass EPDs was to examine the effect of adding a carcass related data. Ribeye Area is viewed as means of indicating the muscularity of the carcasses harvested from potential offspring. The Marbling EPD will relate to the degree of intramuscular fat the carcasses of potential offspring will yield and its potential to obtain quality grade based premiums or be marketed through different branded beef programs. Lastly, the Fat EPD will be of interest to producers that are marketing on yield based systems or those that reward lower numerical yield grades. With the addition of the carcass EPDs the total number of observations was 164 bulls and it should be noted that all of the data from 2008 was removed.

**Empirical Model: (Equation 3: production test + Performance EPDs and Maternal EPDs + Carcass EPD's)**

$$\text{Price} = \beta_0\text{INT} + \beta_1\text{Age} - \beta_2 \text{Agesq} + \beta_3\text{YR2009} + \beta_4\text{YR2010} - \beta_5\text{YR2011} - \beta_6\text{YR2012} + \beta_7\text{BirthWT} + \beta_8\text{TestWT} + \beta_9\text{ADG} + \beta_{10}\text{WDA} + \beta_{11}\text{Ribeye} + \beta_{12}\text{Scrotal} + \beta_{13}\text{Frame} + \beta_{14}\text{CEEPD} - \beta_{15}\text{BWE PD} + \beta_{16}\text{WWE PD} + \beta_{17}\text{YWE PD} + \beta_{18}\text{MCEEPD} + \beta_{19}\text{MMEPD} + \beta_{20}\text{MARBE PD} + \beta_{21}\text{REEPD} - \beta_{22}\text{FatEPD} + \varepsilon_t$$

Where:

Price = Price of Angus bulls sold at auction (\$/head)

INT = Intercept

Age = Age of the bull in days from birth to date of auction

Agesq = Age of bull in days from birth to date of auction squared

YR2009 = 1 if sale of bull occurred in 2009 and = 0 otherwise

YR2010 = 1 if sale of bull occurred in 2010 and = 0 otherwise

YR2011 = 1 if sale of bull occurred in 2011 and = 0 otherwise

YR2012 = 1 if sale of bull occurred in 2012 and = 0 otherwise

BirthWT = Individual birth weight of bull in pounds

TestWT = Individual weight of bull at final weigh date of test (112 days) in pounds

ADG = Average daily gain associated with the individual for the test period

WDA = Weight gain per day of age (birth to completion of testing period) for the individual in pounds

Ribeye = Size of ribeye in square inches from ultrasound

Scrotal = Circumference of scrotum in centimeters

Frame = Frame Score associated with individual bull

CEEPD = Angus Calving Ease Direct EPD

BWEPD = Angus Birth Weight EPD

WWEPD = Angus Weaning Weight EPD

YWEPD = Angus Yearling Weight EPD

MCEPD = Angus Calving Ease Maternal EPD

MMEPD = Angus Maternal Milk EPD

MARBE PD = Angus Marbling EPD

REEPD = Angus Ribeye Area EPD

FatEPD = Angus Fat Thickness EPD

*Price* = Price of Angus bulls at auction is determined by:

*Age* = It is hypothesized that the coefficient will be positive. As this is the age of the individual this can be an indicator of the growth of the individual if they appear to be at



a higher weight than their contemporaries and their readiness to be utilized for breeding. Some buyers will be willing to pay more for a “Senior” bull that they believe is able to enter the herd and breed more females than a “Junior” bull potentially could.

*Agesq* = It is hypothesized that the coefficient will be negative. As was discussed when hypothesizing about the age coefficient there will be a point where buyers will be willing to pay less for each day of age. By the inclusion of the age squared coefficient the non-linear nature of this attribute should be discovered.

*YR2009 – YR2010* = It is hypothesized that the coefficient will be negative as both years have sale averages less than the benchmark year 2013 sale average.

*YR2011 - YR2012* = It is hypothesized that the coefficient will be positive as both years have a sale average greater than the benchmark year of 2013 sale average.

*BirthWt* = it is hypothesized that the coefficient will be negative. This is the actual birth weight of the individual and is an indicator of the potential birth weight of his offspring. As the weight increases so does the potential for calving problems due to dystocia which could make buyers pay less for bulls with higher birth weights.

*TestWt* = It is hypothesized that the coefficient will be positive. Final test weight can be thought of as indicative of the growth potential of the individual. As most people equate weight in cattle with performance those individuals that are at a higher weight within their contemporary groups may be seen as more desirable.

*ADG* = It is hypothesized that the coefficient will be positive. This is the measurement of the average daily body weight change over the course of the testing period. The higher the ADG the more efficient the animal is at converting feed which would be of

interest to producers as this could result in cost savings and more pounds of saleable calf from his offspring resulting in a potential increase to profitability.

*WDA* = It is hypothesized that the coefficient will be positive. An individual with a higher weight per day of age would be of value to a producer as a larger number speak to the growth ability of the animal. Producers could hypothesize that the higher WDA would result in more pounds of calf at marketing resulting in more revenue.

*Ribeye* = It is hypothesized that the coefficient will be positive. The ultra-sound data is of value as it is the best means of establishing a ribeye area for the individual while it is alive. As the ribeye area is an indicator of muscling, an increase in ribeye size would equate to more product of saleable red meat from sired offspring.

*Scrotal* = It is hypothesized that the coefficient will be positive. As this is related to age of puberty of females those producers that retain replacement females will place a premium on those individuals with larger scrotal circumferences. The ability of females to reach first estrus earlier can be bred quicker and can potentially maintain a shorter interval between calving and rebreeding. Those producers that have a terminal production system will more than likely be only concerned that scrotal development is such that viable semen are produced in enough quantity so they can be confident in the individual's ability to breed.

*Frame* = We are unsure as to the sign of this coefficient. This is due to the fact that no frame size is considered perfect and is more to the producer's preference or type and kind of cattle.

*CEEPD* = It is hypothesized that the coefficient will be positive. As this value is the indicative of the potential number of unassisted births associated first calf heifers when

bred to the individual. The higher value would represent a labor savings to the producer and a greater likelihood of a producer getting a live calf.

*BWEPD* = It is hypothesized that the coefficient will be negative. As was discussed with the actual birth weight measurement of the individual, a higher value would mean that calves from mating to the sire could result in heavier weight calves. Heavier calves have more instances of complicated births which a producer will discriminate against. A lower *BWEPD* would be more desirable to producers.

*WWEPD* = It is hypothesized that the coefficient will be positive. Weaning Weight (WW) is the sire's effect on weight at time at weaning. A higher value when compared to a contemporary would be indicative of more saleable pounds at weaning. This increase to growth is economically relevant to producers.

*YWEPD* = It is hypothesized that the coefficient will be positive. Yearling Weight (YW) is the sire's effect on weight yearling growth. A higher value when compared to a contemporary would be indicative of more saleable pounds as a yearling. This increase in growth is economically relevant to producers.

*MCEEPD* = It is hypothesized that the coefficient will be positive. Maternal calving ease is an indicator of the ease of calving for first calf heifers that have been sired by the individual. This would be of mixed value, depending on the mix of buyers at the auction. Those individuals that operate terminal operations will likely not place much emphasis on this EPD when making their selection. However, those that purchase bulls and retain replacement heifers will place emphasis as the higher the value the less instance of troubled calving should be associated with the female. As was discussed with the

calving ease associated with breeding directly to the potential sire, an easy birth saves a producer time, labor and expense.

*MMEPD* = We are unsure as to the sign associated with this coefficient. The maternal milk epd is the portion of a calf's weaning weight that can be associated with the female. A higher value would indicate a heavier milking female, which can be good or bad. A higher milking female will have higher feed requirements to maintain her condition and provide for the calf. In areas with marginal available feed and those areas affected by drought, this increase in feed requirement could result in increased cost for the producer.

*MARBEPD* = It is hypothesized that the coefficient will be positive. An increase in the marbling of a carcass will increase the value of the carcass. As marbling increases the likelihood of the carcass grading in one of the Choice categories would result in increased revenue over those that grade in the Select range. The ability to increase carcass value would make the bull more valuable.

*REEPD* = It is hypothesized that the coefficient will be positive. Ribeye area is an indicator of the degree of muscling. As the Ribeye area increases so would the amount of retail product derived from the fabrication of the carcass. The ability of the sire to increase muscle in his offspring would increase the value of the bull.

*FatEPD* = It is hypothesized the coefficient will be negative. This is measure of the amount of external fat at the 12<sup>th</sup> and 13<sup>th</sup> rib junction. As a certain amount of external fat is required to reach acceptable quality grades, there will be a range of acceptable values. There will become a point where heavily conditioned carcasses will be discounted as they will have higher numerical yield grades associated them. These over-conditioned carcass

have a higher amount of trim and waste associated with them. Therefore as the amount of fat increases the value of this attribute would diminish the price of the bull.

## **CHAPTER V: RESULTS**

A regression analysis was performed on each model utilizing SAS and the results for each model will be discussed in turn in this chapter. Each coefficient will be discussed for each model, as they relate to the dependent variable of Price. The summary statistics for the data analyzed in all three models is located in Table 5.1

**Table 5.1 Summary Statistics**

<b>Simple Statistics</b>						
<b>s</b>	<b>N</b>	<b>Units</b>	<b>Mean</b>	<b>Std Dev</b>	<b>Minimum</b>	<b>Maximum</b>
<b>Year</b>	362	Year	2010	1.67153	2008	2013
<b>Age</b>	362	Days	414.8039	57.751	328	540
<b>YR2008</b>	362	Year	0.17403	0.37966	0	1
<b>YR2009</b>	362	Year	0.16298	0.36986	0	1
<b>YR2010</b>	362	Year	0.17127	0.37727	0	1
<b>YR2011</b>	362	Year	0.18232	0.38664	0	1
<b>YR2012</b>	362	Year	0.17127	0.37727	0	1
<b>BirthWt</b>	362	Pounds	75.64088	9.68697	45	105
<b>TestWt</b>	362	Pounds	1298	157.7682	933	1826
<b>ADG</b>	362	Pounds	4.40499	0.6269	2.77	6.49
<b>WDA</b>	362	Pounds	3.48243	2.60584	2.38	52.53
<b>Ribeye</b>	362	Sq. inches	12.8047	1.65174	8.7	17.8
<b>Scrotal</b>	362	Cm	39.03867	3.21783	13	53
<b>Frame</b>	362	score	6.22072	0.68767	4.5	8.9
<b>EPDinCat</b>	362	dummy	0.98066	0.1379	0	1
<b>Price</b>	362	Dollars	2360	896.5364	650	6200
<b>CEEPD</b>	334	EPD	6.27485	3.20248	-7	14
<b>BWEPD</b>	352	EPD	1.63474	1.42845	-5	10
<b>WWEPD</b>	353	EPD	44.9915	8.04938	4	86
<b>YWEPD</b>	339	EPD	83.69027	12.63887	47	114
<b>MCEEPD</b>	298	EPD	6.9104	2.98412	-3	18
<b>MMEPD</b>	309	EPD	21.5078	8.17585	-0.16	84
<b>CWEPD</b>	216	EPD	14.30759	10.09758	-4	53
<b>MARBEPD</b>	266	EPD	5.19278	9.62971	-0.08	65
<b>REEPD</b>	206	EPD	0.31704	1.3932	-0.19	20
<b>FatEPD</b>	168	EPD	0.00882	0.01816	-0.038	0.101
<b>DolW</b>	293	EPD	23.43706	15.46141	-6.94	220.01
<b>DolF</b>	251	EPD	26.38327	12.32352	-12	68.3
<b>DolG</b>	197	EPD	19.01363	13.96574	-0.18	52.95
<b>DolQG</b>	197	EPD	15.53699	11.60989	-0.3	41.89
<b>DolYG</b>	197	EPD	3.45771	3.50575	-4.9	13.14
<b>DolB</b>	142	EPD	52.82352	16.2004	10.76	92.75
<b>Agesq</b>	362	EPD	175388	50112	107584	291600

Correlation tables were created for each of the three models as well and are located in the appendix. Those values that were highly correlated (>90%) were of a nature that should be expected. The only variables that showed consistent correlation across all three models were age and age squared. As the age is used in the calculation of age squared this was of no surprise.

### **5.1 Regression Results**

The coefficient for each independent variable will be discussed and the t-stat and P-value will be presented in order to discuss the significance from zero and their ability to be utilized in the determination of the final price paid for each bull. Each model was analyzed to determine if the model suffered from issues related to heteroscedasticity as this can be an issue with this type of model. No issues were found in any of the three models as evidence as the probability of the Chi squared values is above 95 percent for all three.

### **5.2 Equation 1: Results**

Results for the estimated regression for Angus bulls sold at the OPSU bull test auction for the production test related variables are located in table 5.2.



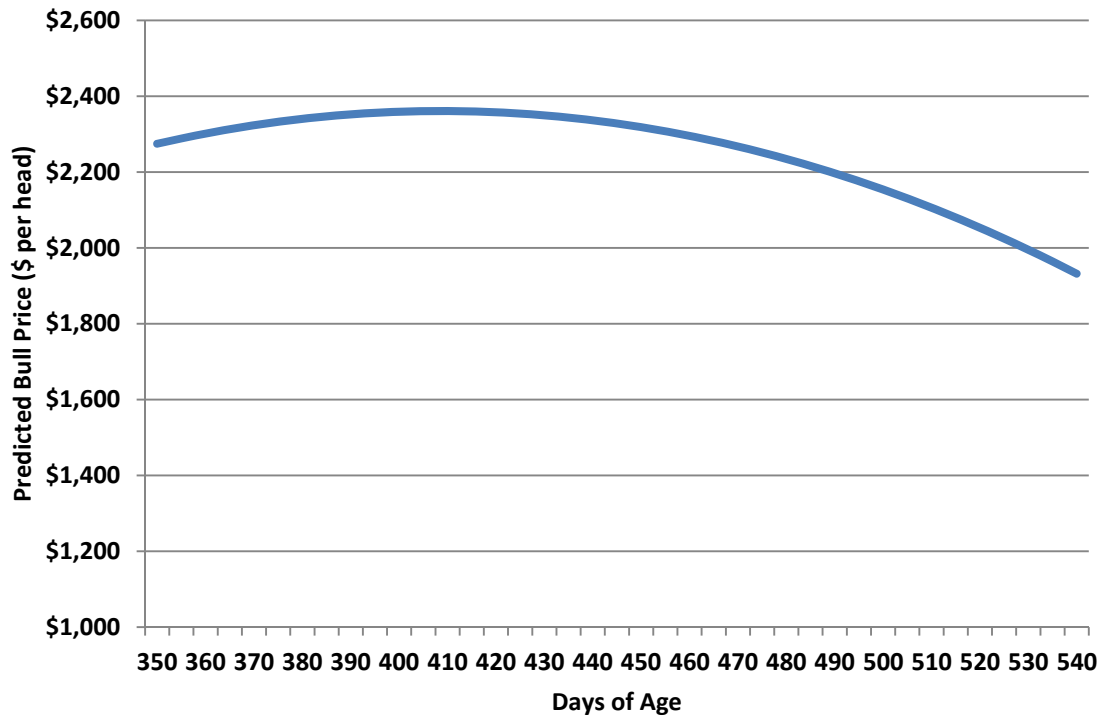
**Table 5.2 Coefficient Estimates of Angus Bull Price Determinants for Performance Test Attributes**

<b>Variables</b>	<b>Coefficient</b>	<b>t-stat</b>	<b>P-Value</b>
Intercept	-6401.496		
Age	20.39*	1.76	.0079
Age Squared	-0.03*	-1.87	0.062
<b>Year</b>			
2008	-258.95**	-1.99	0.047
2009	-720.76***	-5.54	0.000
2010	-552.16***	-4.04	0.000
2011	492.91***	3.65	0.000
2012	507.92***	3.67	0.000
<b>Performance Test Data</b>			
Birth Weight	-19.82***	-5.09	0.000
Final Test Weight	2.08***	3.48	0.000
Average Daily Gain	478.8***	5.55	0.000
Weight per Day of Age	1.35	0.1	0.92
Ribeye Area - Ultrasound	48.99*	1.67	0.097
Scrotal Circumference	1.46	0.12	0.902
Frame Score	92.27	1.52	0.129
EPD in Catalog	194.72	0.76	0.451
R-Square	0.4859		
Adjusted R-Square	0.4636		
Observations	362		
* = significance from zero at 0.10 level			
** = significance from zero at 0.05 level			
*** = significance from zero at 0.01 level			

The variables for age and age squared were highly correlated (index figure) as could be expected as age squared is derived from the age value. Given this high degree of correlation and their effect on each other their results will be discussed together.

The coefficient for age is 20.39 with a P-value  $\leq 0.10$  indicating that the coefficient is significant from zero and we can be 90% certain is a determinant of final price paid for Angus bulls sold. The positive coefficient was as hypothesized as we believed that buyers were willing to pay more for older bulls. This willingness we believe is due to the fact that a more mature bull can be placed with a higher number of females to breed and may have a better conception rate than that of a younger bull placed with comparable females. The coefficient for age squared is -0.03 and the P-value is  $\leq 0.10$  indicating that the coefficient is significant from zero and we can be 90% certain is a determinant of final price paid for Angus bulls sold. The negative coefficient on Agesq was as hypothesized. We believed that buyers would pay more to go from a Junior division bull to a Senior Division bull but believed that the age premium would decrease. Given the correlation the effect on the final price for Angus bulls sold can be better evaluated in Figure 5.2

**Figure 5.1 Predicted Bull Price vs Bull Age**



The graph in figure 5.2 shows that initially buyers are willing to pay an increasing amount for each day of age as evidenced by the positive coefficient on the Age variable but this amount declines over time and buyer are less willing to pay for each day of age after a certain point. This effect is caused by the negative coefficient on the Agesq variable resulting in the shape of the curve.

The coefficient for sale year 2008 is -258.95, suggesting that the fact that a bull sold in 2008 compared to the benchmark year of 2013 would decrease the price by \$258.95 per head. The P-value is  $\leq 0.10$  indicating that this coefficient is significant from zero and we can be 90% certain that this variable is a determinant of final price for Angus bulls sold. This would indicate that bulls sold in 2008 would have a decreased price compared to those sold in the benchmark year of 2013. The sign on the coefficient was not as expected. It

was hypothesized that the sign on the coefficient YR2008 would be positive as the sale average in 2008 was greater than the average in 2013.

The coefficient for sale year 2009 is -720.76, suggesting that the fact that a bull sold in 2009 compared to the benchmark year of 2013 would decrease the price by \$720.76 per head. The P-value is  $\leq 0.01$  indicating that this coefficient is significant from zero and we can be 99% certain that this variable is a determinant of final price for Angus bulls sold. The sign on the coefficient was negative as was hypothesized.

The coefficient for sale year 2010 is -552.16, suggesting that the fact that a bull sold in 2010 compared to the benchmark year of 2013 would decrease the price by \$552.16 per head. The P-value is  $\leq 0.01$  indicating that this coefficient is significant from zero and we can be 99% certain that this variable is a determinant of final price for Angus bulls sold. The sign on the coefficient was negative as was hypothesized.

The coefficient for sale year 2011 is 492.91, suggesting that the fact that a bull sold in 2011 compared to the benchmark year of 2013 would increase the price by \$492.91 per head. The P-value is  $\leq 0.01$  indicating that this coefficient is significant from zero and we can be 99% certain that this variable is a determinant of final price for Angus bulls sold. The sign on the coefficient was positive as hypothesized as the sale average in 2011 was higher than the benchmark year of 2013.

The coefficient for sale year 2012 is 507.92, suggesting that the fact that a bull sold in 2012 compared to the benchmark year of 2013 would increase the price by \$507.92 per head. The P-value is  $\leq 0.01$  indicating that this coefficient is significant from zero and we can be 99% certain that this variable is a determinant of final price for Angus bulls sold. The sign on the coefficient for YR2012 was positive as hypothesized.

The coefficient for Birth Weight is -19.82, suggesting that each pound of birth weight associated with the bull will decrease the price by \$19.82 per head. The P-value is  $\leq 0.01$  indicating that this coefficient is significant from zero and we can be 99% certain that this variable is a determinant of final price for Angus bulls sold. The sign associated with the coefficient for Birth Weight is negative as was hypothesized. Individuals that have heavier birth weights could in turn sire calves with higher birth weights. The producers would find the higher birth weights less desirable as there is more potential for complicated births. The fewer complicated deliveries a producer has to contend with will lead to a decrease in labor and cost and a have a greater likelihood of a live calf.

The coefficient for Final Test Weight is 2.08 suggesting that for each pound of weight associated with the bull will increase the price by \$2.08 per head. The P-value is  $\leq 0.01$  indicating that this coefficient is significant from zero and we can be 99% certain that this variable is a determinant of final price for Angus bulls sold. The sign associated with the coefficient for Final Test Weight was positive as hypothesized. Weight has long been a way for producers to visualize the performance and physiological age for an animal. Those that were at higher weights could be perceived by producers to be higher performing individuals and that the offspring from these sires would have more growth potential. The ability to be more efficient and have greater gains would be of financial importance to producers. The ability to impart the potential for heavier calves could increase a producer's profitability.

The coefficient for Average Daily Gain is 478.80 suggesting for each pound of average daily gain associated with the bull will increase price by \$478.80 per head. The P-value is  $\leq 0.01$  indicating that this coefficient is significant from zero and we can be 99%

certain that this variable is a determinate of final price for Angus bulls sold. The sign associated with the coefficient for ADG was positive as hypothesized. The ability of an individual to more efficiently convert feed to lbs of animal would be a very desirable trait that producers would be willing to pay a premium for. Those sires that have a higher average daily gain could potentially sire calves that could increase the profitability of a producer by siring quicker growing calves that require less feed.

The coefficient for Weight per Day of Age is 1.35, suggesting that for each pound of daily gain for the life of the bull will increase price by \$1.35 per head. The P-value is  $\geq 0.10$  indicating this coefficient is not statistically significant in determining the price paid for Angus bulls. The sign associated with the coefficient for WDA was positive as hypothesized. The fact that the coefficient for WDA was not statistically significant was unexpected. We believed that this would be significant as it is an indicator of growth over the life of the individual bull. Other growth related factors were highly significant so it may indicate that producers are more comfortable evaluating the growth associated with the animal just during the feeding period of the test as was evidenced by the significance of the ADG variable.

The coefficient for ultrasound Ribeye area is 48.99, suggesting that for each square inch of ribeye area the price will increase by \$48.99 per head. The P-value is  $\leq 0.10$  indicating this coefficient is statistically significant from zero and we can be 90% certain that this variable is a determinate of final price for Angus bulls sold. The sign associated with the coefficient for Ribeye area was positive as hypothesized. The Ribeye area ultrasound size is an indicator of muscularity. Those calves with larger ribeye areas will

have carcasses that have a higher percentage of saleable retail product when harvested and as such could bring a producer more revenue for utilizing a sire with a larger ribeye area.

The coefficient for Scrotal Circumference is 1.46, suggesting that for each centimeter of scrotal circumference the price will increase by \$1.46 per head. The P-value is  $\geq 0.10$  indicating this coefficient is not statistically significant in determining the price paid for Angus bulls. The sign associated with the coefficient for Scrotal Circumference was positive as hypothesized.

The coefficient for Frame Score is 92.27, suggesting that for each one unit of increase in the numerical frame score the price will increase by \$92.27 per head. The P-value is  $\geq 0.10$  indicating this coefficient is not statistically significant in determining the price paid for Angus bulls. The sign associated with the coefficient for Frame Score was positive. Initially we did not have a feeling for the sign associated with the coefficient for Frame Score as there can be benefits associated with both large and small framed cattle. It would appear that producers would prefer larger frame cattle.

The coefficient for EPDs in the sale Catalog is 194.72, suggesting that the fact that an individual bull had EPDs in the printed catalog increased price by \$194.72 per head. The P-value is  $\geq 0.10$  indicating that this coefficient is not statistically significant in determining the price paid for Angus bulls. The sign associated with the coefficient for EPDinCat was as hypothesized. We did have a feeling that this coefficient would have been statistically significant as having EPDs available would be beneficial to the buyer by giving the potential buyer an idea of the genetic potential of a sire.

### **5.3 Equation 2: Results**

The results for the regression analysis of equation 2 are presented in Table 5.1.

**Table 5.3 Results of Equation 2**

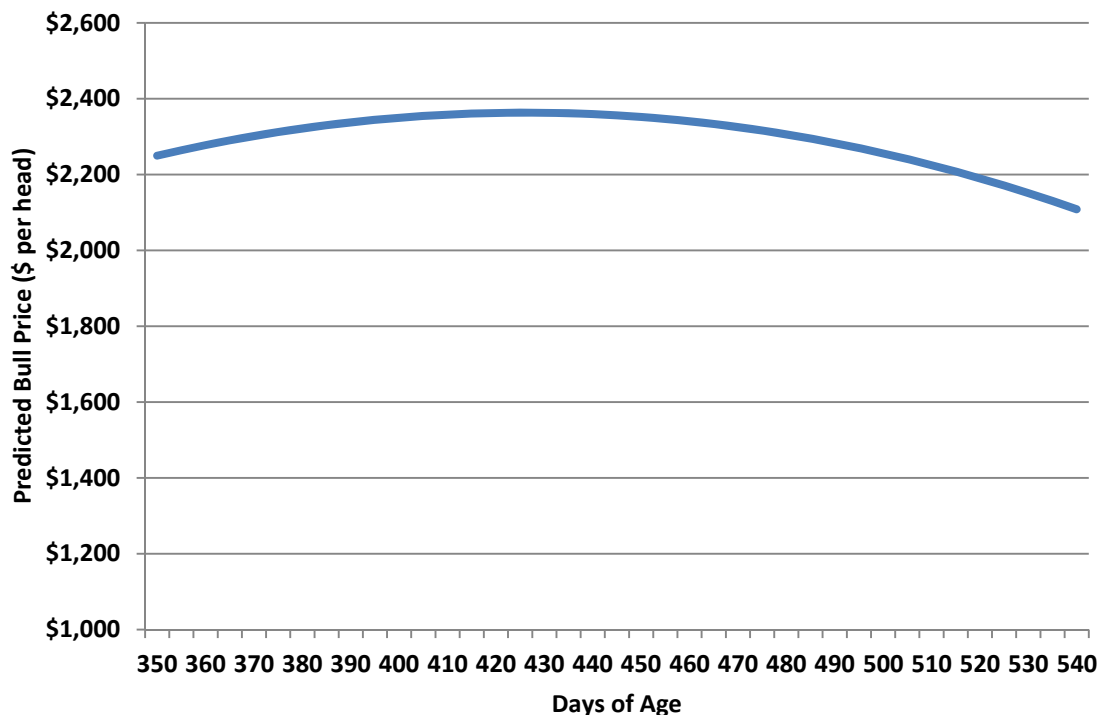
<b>Variables</b>	<b>Coefficient</b>	<b>t-stat</b>	<b>P-Value</b>
Intercept	-5103.787		
Age	16.73	1.26	0.207
Age Squared	-0.02	-1.3	0.196
<b>Year</b>			
2008	-120.01	-0.41	0.681
2009	-630.94***	-4.31	0.000
2010	-431.04***	-2.83	0.005
2011	553.51***	3.89	0.000
2012	546.85***	3.78	0.000
<b>Performance Test Data</b>			
Birth Weight	-16.31***	-3.63	0.000
Final Test Weight	1.72**	2.57	0.011
Average Daily Gain	433.76***	4.64	0.000
Weight per Day of Age	-2.02	-0.15	0.877
Ribeye Area - Ultrasound	49.19	1.49	0.137
Scrotal Circumference	-14.26	-1.14	0.254
Frame Score	101.79	1.46	0.144
<b>Performance EPDs</b>			
Calving Ease Direct	49.85**	2.2	0.029
Birth Weight EPD	-24.94	-0.52	0.605
Weaning Weight EPD	4.05	0.36	0.717
Yearling Weight EPD	0.04	0	0.996
<b>Maternal EPDS</b>			
Calving Ease Maternal	-13.10	-0.57	0.57
Maternal Milk	0.32	0.05	0.96
R-Square	0.5124		
Adjusted R-Square	0.4761		
Observations	290		
* = significance from zero at 0.10 level			
** = significance from zero at 0.05 level			
*** = significance from zero at 0.01 level			

The variables for Age and Agesq were highly correlated (index figure) as could be expected as age squared is derived from the age value. Given this high degree of correlation and their effect on each other their results will be discussed together.



The coefficient for age is 16.73 with a P-value  $\geq 0.10$  indicating that the coefficient is not significant from zero and is not a determinant of final price paid for Angus bulls sold. The positive coefficient was as hypothesized as we believed that buyers were willing to pay more for older bulls. This willingness we believe is due to the fact that a more mature bull can be placed with a higher number of females to breed and may have a better conception rate than that of a younger bull placed with comparable females. The coefficient for age squared is -0.02 and the P-value is  $\geq 0.10$  indicating that the coefficient is not significant from zero is not a determinant of final price paid for Angus bulls sold. The negative coefficient on Agesq was as hypothesized. We believed that buyers would pay more to go from a Junior division bull to a Senior Division bull but believed that the age premium would decrease. Given the correlation the effect on the final price for Angus bulls sold can be better evaluated in Figure 5.3

**Figure 5.2 Predicted Bull Price vs Bull Age Model 2**



The graph in figure 5.3 shows that initially buyers are willing to pay an increasing amount for each day of age as evidenced by the positive coefficient on the Age variable but this amount declines over time and buyers are less willing to pay for each day of age after a certain point. This effect is caused by the negative coefficient on the Agesq variable resulting in the shape of the curve.

While the graph illustrates the effect on final price of Angus bulls that was hypothesized, what was not expected was the fact that Age and Agesq would become not statistically significant.

The coefficient for sale year 2008 is -120.01, suggesting that the fact that a bull sold in 2008 compared to the benchmark year of 2013 would decrease the price by \$120.01 per head. The P-value is  $\geq 0.10$  indicating that this coefficient is not statistically significant in determining the final price for Angus bulls sold. The sign on the coefficient was not as expected. It was hypothesized that the sign on the coefficient YR2008 would be positive as the sale average in 2008 was greater than the average in 2013.

The coefficient for sale year 2009 is -630.94, suggesting that the fact that a bull sold in 2009 compared to the benchmark year of 2013 would decrease the price by \$630.94 per head. The P-value is  $\leq 0.01$  indicating that this coefficient is significant from zero and we can be 99% certain that this variable is a determinant of final price for Angus bulls sold. The sign on the coefficient was as negative as was hypothesized.

The coefficient for sale year 2010 is -431.04, suggesting that the fact that a bull sold in 2010 compared to the benchmark year of 2013 would decrease the price by \$431.04 per head. The P-value is  $\leq 0.01$  indicating that this coefficient is significant from zero and we

can be 99% certain that this variable is a determinant of final price for Angus bulls sold. The sign on the coefficient was as negative as was hypothesized.

The coefficient for sale year 2011 is 553.51, suggesting that the fact that a bull sold in 2011 compared to the benchmark year of 2013 would increase the price by \$553.51 per head. The P-value is  $\leq 0.01$  indicating that this coefficient is significant from zero and we can be 99% certain that this variable is a determinant of final price for Angus bulls sold. The sign associated with the coefficient for YR2011 is positive as hypothesized.

The coefficient for sale year 2012 is 546.85, suggesting that the fact that a bull sold in 2012 compared to the benchmark year of 2013 would increase the price by \$546.85 per head. The P-value is  $\leq 0.01$  indicating that this coefficient is significant from zero and we can be 99% certain that this variable is a determinant of final price for Angus bulls sold. The sign associated with the coefficient for YR2012 was positive as hypothesized.

The coefficient for Birth Weight is -16.31, suggesting that each pound of birth weight associated with the bull will decrease the price by \$16.31 per head. The P-value is  $\leq 0.01$  indicating that this coefficient is significant from zero and we can be 99% certain that this variable is a determinant of final price for Angus bulls sold. The sign associated with the coefficient for Birth Weight is negative as was hypothesized. Individuals that have heavier birth weights could in turn sire calves with higher birth weights. The producers would find the higher birth weights less desirable as there is more potential for complicated births. The fewer complicated deliveries a producer has to contend with will lead to a decrease in labor and cost and a have a greater likelihood of a live calf.

The coefficient for Final Test Weight is 1.72 suggesting that for each pound of weight associated with the bull will increase the price by \$1.72 per head. The P-value is

$\leq 0.05$  indicating that this coefficient is significant from zero and we can be 95% certain that this variable is a determinant of final price for Angus bulls sold. The sign associated with the coefficient for Final Test Weight was positive as hypothesized. Weight has long been a way for producers to visualize the performance and physiological age for an animal. Those that were at higher weights could be perceived by producers to be higher performing individuals and that the offspring from these sires would have more growth potential. The ability to be more efficient and have greater gains would be of financial importance to producers. The ability to impart the potential for heavier calves could increase a producer's profitability.

The coefficient for Average Daily Gain is 433.76 suggesting for each pound of average daily gain associated with the bull will increase price by \$433.76 per head. The P-value is  $\leq 0.01$  indicating that this coefficient is significant from zero and we can be 99% certain that this variable is a determinate of final price for Angus bulls sold. The sign associated with the coefficient for ADG was as hypothesized. The ability of an individual to more efficiently convert feed to lbs of animal would be a very desirable trait that producers would be willing to pay a premium for. Those sires that have a higher average daily gain could potentially sire calves that could increase the profitability of a producer by siring quicker growing calves that require less feed.

The coefficient for Weight per Day of Age is -2.02, suggesting that for each pound of daily gain for the life of the bull will decrease price by \$2.02 per head. The P-value is  $\geq 0.10$  indicating this coefficient is not statistically significant in determining the price paid for Angus bulls. The sign on the coefficient for WDA is not as hypothesized. The original hypothesis was that the sign would be positive. The sign was believed to be positive

because a higher value would indicate more growth per day of the bulls life. I cannot explain the negative sign as this is counter to our beliefs.

The coefficient for ultrasound Ribeye area is 49.19, suggesting that for each square inch of ribeye area the price will increase by \$49.19 per head. The P-value is  $\geq 0.10$  indicating this coefficient is not statistically significant in determining the final price for Angus bulls sold. The sign associated with the coefficient for Ribeye area was positive as hypothesized. The Ribeye area ultrasound size is an indicator of muscularity. Those calves with larger ribeye areas will have carcasses that have a higher percentage of saleable retail product when harvested and as such could bring a producer more revenue for utilizing a sire with a larger ribeye area.

The coefficient for Scrotal Circumference is -14.26, suggesting that for each centimeter of scrotal circumference the price will decrease by \$14.26 per head. The P-value is  $\geq 0.10$  indicating this coefficient is not statistically significant in determining the price paid for Angus bulls. The sign associated with the coefficient for Scrotal Circumference was not as hypothesized. This is a change from the first equation. The sign associated with the Scrotal Circumference coefficient is negative in Equation 2. The original hypothesis was a positive sign as a larger scrotal circumference results in an earlier onset of puberty in female offspring which should be a desirable attribute. Those producers who operate a terminal operation should be at the most indifferent to the scrotal circumference so the negative sign is unexpected.

The coefficient for Frame Score is 101.79, suggesting that for each one unit of increase in the numerical frame score the price will increase by \$101.79 per head. The P-value is  $\geq 0.10$  indicating this coefficient is not statistically significant in determining the

price paid for Angus bulls. The sign associated with the coefficient for Frame Score was positive. Initially we did not have a feeling for the sign associated with the coefficient for Frame Score as there can be benefits associated with both large and small framed cattle. It would appear that producers would prefer larger frame cattle.

The coefficient for Calving Ease Direct EPD is 49.85 suggesting that as the EPD increases the price will increase by \$49.85. The P-value is  $\leq 0.05$  indicating that this coefficient is significant from zero and we can be 95% certain that this variable is a determinate of final price for Angus bulls. The sign associated with the coefficient for CEEPDP is positive as hypothesized. The Calving Ease Direct EPD speaks to the number of unassisted births associated with breeding to the individual bulls. As the value increases the fewer incidents of complicated births should arise. This can reduce stress, labor and costs for a producer.

The coefficient for Birth Weight EPD is -24.94, suggesting that for as pounds increase the price will decrease by \$24.94. The P-value is  $\geq 0.10$  indicating this coefficient is not statistically significant in determining the price paid for Angus bulls. The sign associated with the coefficient for BWEPDP is negative as hypothesized. The fact that this value is not statistically significant is not totally surprising. The variable for the individual bull's actual birth weight was statistically significant which would lead me to believe that producers place more value on the bull's actual birth weight as a predictor of the weight of calves that he will sire.

The coefficient for Weaning Weight EPD is 4.05, suggesting that as each pound of weaning weight increases the price will increase by \$4.05 per head. The P-value is  $\geq 0.10$  indicating this coefficient is not statistically significant in determining the price paid for

Angus bulls. The sign associated with the coefficient for WVEPD is positive as hypothesized.

The coefficient for Yearling Weight EPD is 0.04, suggesting that as each pound of yearling weight increases the price will increase by \$0.04 per head. The P-value is  $\geq 0.10$  indicating this coefficient is not statistically significant in determining the price paid for Angus bulls. The sign associated with the coefficient for YWEPD is positive as hypothesized.

The coefficient for Calving Ease Maternal EPD is -13.10 suggesting that as the percentage increases the price will decrease by \$13.10. The P-value is  $\geq 0.10$  indicating this coefficient is not statistically significant in determining the price paid for Angus bulls. The sign associated with the coefficient for MCE is not as hypothesized. As this is a measure of the ease of calving associated with the sire's grand progeny the fact that it is not statistically significant is not surprising. The negative sign is not as expected as the value increases the number of assisted births would decrease.

The coefficient for Maternal Milk EPD is 0.32 suggesting that for each unit of increase the price will increase by \$0.32 per head. The P-value is  $\geq 0.10$  indicating this coefficient is not statistically significant in determining the price paid for Angus bulls. The sign associated with the coefficient for MM is positive. We were unsure as to the sign because the EPD can be interpreted differently by producers. While this variable is not statistically significant in determining the final price paid for Angus bulls it appears that the extra growth associated with the dam is viewed as a desirable trait.

#### **5.4 Result Comparison**

Comparing the results between Equation 1 and Equation 2 some of the changes of note are that several independent variables that were significant at the  $P \leq 0.10$  level or less

became insignificant with P values that were  $P \geq 0.10$ . Those variables that were no longer of statistical significance are: Age, Age squared, Yr2008 and Ribeye Area. The variable for test weight changed as well moving from a P value of 0.0006 in Equation 1 to a P value of 0.0107 in Equation 2. The earlier years of the study (2008 and 2009) tended to have fewer EPDs associated with bulls sold in these years. As there were fewer individuals in Model 2 from those two years it can be inferred that their significance dropped due to lack of representation in Equation 2. It is surprising that the two age related variables were no longer statistically significant price determinants. Physical growth has long been a way for producers to evaluate age, (i.e. a certain weight is associated with weaned calves) so the continued statistical significance of ADG and final test weight may be of more importance to producers than the actual age in days of the bulls.

#### Equation 3: Results

The results for regression analysis of Equation 3 are found in table 5.4



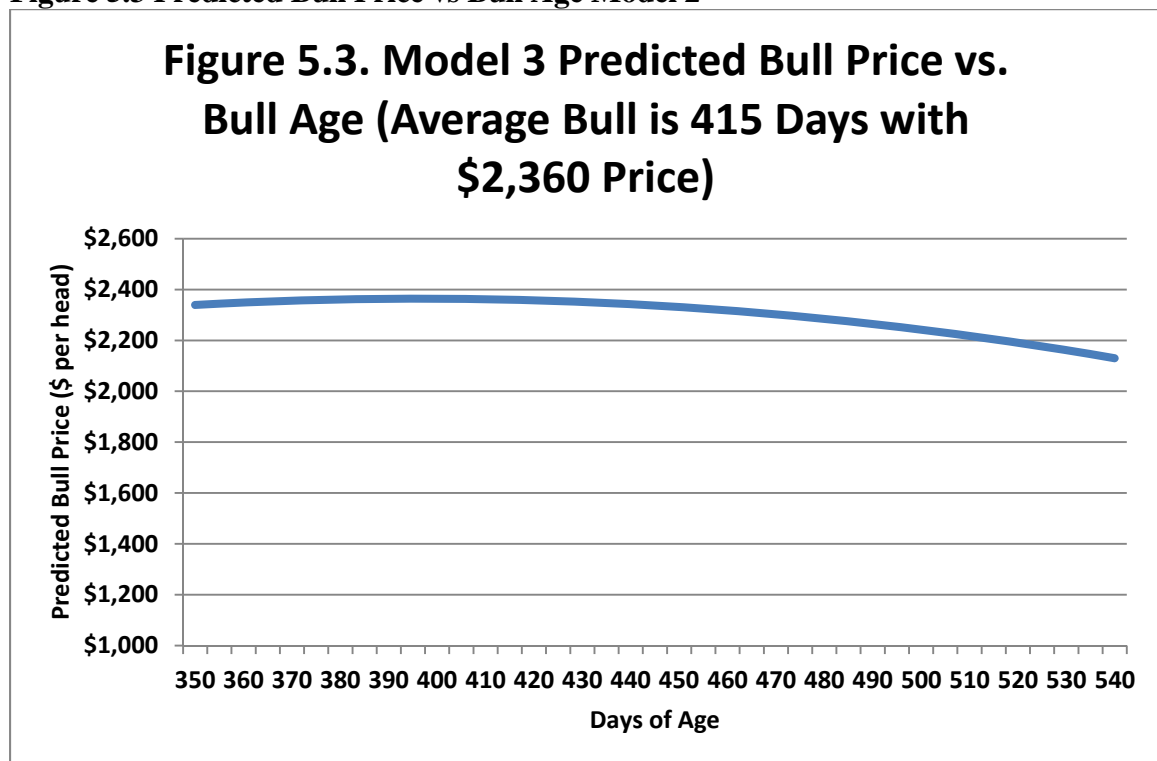
**Table 5.4 Results of Equation 3**

<b>Variables</b>	<b>Coefficient</b>	<b>t-stat</b>	<b>P-Value</b>
Intercept	-4666.03		
Age	9.02	0.39	0.697
Age Squared	-0.01	-0.53	0.6
<b>Year</b>			
2009	-337.98	-1.11	0.270
2010	-200.31	-0.93	0.352
2011	781.89***	3.49	0.000
2012	841.68***	4.23	0.000
<b>Performance Test Data</b>			
Birth Weight	-24.18***	-3.43	0.000
Final Test Weight	1.72*	1.81	0.073
Average Daily Gain	555.01***	4.1	0.000
Weight per Day of Age	1.37	0.1	0.922
Ribeye Area - Ultrasound	56.64	1.19	0.235
Scrotal Circumference	23.38	0.84	0.401
Frame Score	114.06	1.16	0.246
<b>Performance EPDs</b>			
Calving Ease Direct	54.45	1.51	0.132
Birth Weight EPD	4.75	0.07	0.942
Weaning Weight EPD	1.83	0.14	0.892
Yearling Weight EPD	-2.87	-0.31	0.754
<b>Maternal EPDs</b>			
Calving Ease Maternal	-2.38	-0.07	0.943
Maternal Milk	-2.27	-0.16	0.875
<b>Carcass EPDs</b>			
Marbling EPD	11.21	1.01	0.313
Ribeye Area EPD	665.58*	1.91	0.057
Fat EPD	3005.06	0.94	0.347
R-Square	0.5081		
Adjusted R-Square	0.4313		
Observations	164		
* = significance from zero at 0.10 level			
** = significance from zero at 0.05 level			
*** = significance from zero at 0.01 level			

The variables for Age and Agesq were highly correlated (index figure) as could be expected as age squared is derived from the age value. Given this high degree of correlation and their effect on each other their results will be discussed together.

The coefficient for age is 9.02 with a P-value  $\geq 0.10$  indicating that the coefficient is not significant from zero and is not a determinant of final price paid for Angus bulls sold. The positive coefficient was as hypothesized as we believed that buyers were willing to pay more for older bulls. This willingness we believe is due to the fact that a more mature bull can be placed with a higher number of females to breed and may have a better conception rate than that of a younger bull placed with comparable females. The coefficient for age squared is -0.013 and the P-value is  $\geq 0.10$  indicating that the coefficient is not significant from zero is not a determinant of final price paid for Angus bulls sold. The negative coefficient on Agesq was as hypothesized. We believed that buyers would pay more to go from a Junior division bull to a Senior Division bull but believed that the age premium would decrease. Given the correlation the effect on the final price for Angus bulls sold can be better evaluated in Figure 5.3

**Figure 5.3 Predicted Bull Price vs Bull Age Model 2**



The graph in figure 5.3 shows that initially buyers are willing to pay an increasing amount for each day of age as evidenced by the positive coefficient on the Age variable but this amount declines over time and buyers are less willing to pay for each day of age after a certain point. This effect is caused by the negative coefficient on the Agesq variable resulting in the shape of the curve.

While the graph illustrates the effect on final price of Angus bulls that was hypothesized, what was not expected was the fact that Age and Agesq would become not statistically significant.

The coefficient for sale year 2009 is -337.99, suggesting that the fact that a bull sold in 2009 compared to the benchmark year of 2013 would decrease the price by \$337.99 per head. The P-value is  $\geq 0.10$  indicating that this coefficient is not significantly significant in determining final price for Angus bulls sold. The sign on the coefficient was negative as was hypothesized.

The coefficient for sale year 2010 is -200.31, suggesting that the fact that a bull sold in 2010 compared to the benchmark year of 2013 would decrease the price by \$200.31 per head. The P-value is  $\geq 0.10$  indicating that this coefficient is not significantly significant in determining final price for Angus bulls sold. The sign on the coefficient YR2010 was negative as was hypothesized.

The coefficient for sale year 2011 is 781.89, suggesting that the fact that a bull sold in 2011 compared to the benchmark year of 2013 would increase the price by \$781.89 per head. The P-value is  $\leq 0.01$  indicating that this coefficient is significant from zero and we

can be 99% certain that this variable is a determinant of final price for Angus bulls sold. The sign associated with the coefficient for YR2011 was positive as hypothesized.

The coefficient for sale year 2012 is 841.68, suggesting that the fact that a bull sold in 2012 compared to the benchmark year of 2013 would increase the price by \$841.68 per head. The P-value is  $\leq 0.01$  indicating that this coefficient is significant from zero and we can be 99% certain that this variable is a determinant of final price for Angus bulls sold. The sign associated with the coefficient for YR2012 was positive as hypothesized.

The coefficient for Birth Weight is -24.18, suggesting that each pound of birth weight associated with the bull will decrease the price by \$24.18 per head. The P-value is  $\leq 0.01$  indicating that this coefficient is significant from zero and we can be 99% certain that this variable is a determinant of final price for Angus bulls sold. The sign associated with the coefficient for Birth Weight is negative as was hypothesized. Individuals that have heavier birth weights could in turn sire calves with higher birth weights. The producers would find the higher birth weights less desirable as there is more potential for complicated births. The fewer complicated deliveries a producer has to contend with will lead to a decrease in labor and cost and a have a greater likelihood of a live calf.

The coefficient for Final Test Weight is 1.72 suggesting that for each pound of weight associated with the bull will increase the price by \$1.72 per head. The P-value is  $\leq 0.10$  indicating that this coefficient is significant from zero and we can be 90% certain that this variable is a determinant of final price for Angus bulls sold. The sign associated with the coefficient for Final Test Weight was positive as hypothesized. Weight has long been a way for producers to visualize the performance and physiological age for an animal. Those that were at higher weights could be perceived by producers to be higher performing

individuals and that the offspring from these sires would have more growth potential. The ability to be more efficient and have greater gains would be of financial importance to producers. The ability to impart the potential for heavier calves could increase a producer's profitability.

The coefficient for Average Daily Gain is 555.01 suggesting for each pound of average daily gain associated with the bull will increase price by \$555.01 per head. The P-value is  $\leq 0.01$  indicating that this coefficient is significant from zero and we can be 99% certain that this variable is a determinate of final price for Angus bulls sold. The sign associated with the coefficient for ADG was as hypothesized. The ability of an individual to more efficiently convert feed to lbs of animal would be a very desirable trait that producers would be willing to pay a premium for. Those sires that have a higher average daily gain could potentially sire calves that could increase the profitability of a producer by siring quicker growing calves that require less feed.

The coefficient for Weight per Day of Age is -1.37, suggesting that for each pound of daily gain for the life of the bull will decrease price by \$1.37 per head. The P-value is  $\geq 0.10$  indicating this coefficient is not statistically significant in determining the price paid for Angus bulls. The sign associated with the coefficient for WDA was positive as hypothesized. The fact that the coefficient for WDA was not statistically significant was unexpected. We believed that this would be significant as it is an indicator of growth over the life of the individual bull. Other growth related factors were highly significant so it may indicate that producers are more comfortable evaluating the growth associated with the animal just during the feeding period of the test as was evidenced by the significance of the ADG variable.

The coefficient for ultrasound Ribeye area is 56.64, suggesting that for each square inch of ribeye area the price will increase by \$56.64 per head. The P-value is  $\geq 0.10$  indicating this coefficient is not statistically significant in determining the final price for Angus bulls sold.

The coefficient for Scrotal Circumference is -23.38, suggesting that for each centimeter of scrotal circumference the price will decrease by \$23.38 per head. The P-value is  $\geq 0.10$  indicating this coefficient is not statistically significant in determining the price paid for Angus bulls. The sign associated with the coefficient for Ribeye area was positive as hypothesized.

The coefficient for Frame Score is 114.06, suggesting that for each one unit of increase in the numerical frame score the price will increase by \$114.06 per head. The P-value is  $\geq 0.10$  indicating this coefficient is not statistically significant in determining the price paid for Angus bulls. The sign associated with the coefficient for Frame Score was positive. Initially we did not have a feeling for the sign associated with the coefficient for Frame Score as there can be benefits associated with both large and small framed cattle. It would appear that producers would prefer larger frame cattle.

The coefficient for Calving Ease Direct EPD is 54.45 suggesting that as the EPD increases the price will increase by \$54.45. The P-value is  $\geq 0.10$  indicating this coefficient is not statistically significant in determining the price paid for Angus bulls. The sign associated with the coefficient for CEEPDP is positive as hypothesized.

The coefficient for Birth Weight EPD is 4.75, suggesting that for as pounds increase the price will increase by \$4.75. The P-value is  $\geq 0.10$  indicating this coefficient is not statistically significant in determining the price paid for Angus bulls. The sign

associated with the coefficient for BWEPD is not as hypothesized. It was hypothesized that the coefficient would be negative and was negative in the first two equations. As a higher birth weight EPD would be indicative of a heavier weight calf at birth which could result in complicated births increasing costs and calf mortality a higher BWEPD would not be something I believe a producer would be willing to pay for.

The coefficient for Weaning Weight EPD is 1.83, suggesting that as each pound of weaning weight increases the price will increase by \$1.83 per head. The P-value is  $\geq 0.10$  indicating this coefficient is not statistically significant in determining the price paid for Angus bulls. The sign associated with the coefficient for WVEPD is positive as hypothesized.

The coefficient for Yearling Weight EPD is -2.87, suggesting that as each pound of yearling weight increases the price will decrease by \$2.87 per head. The P-value is  $\geq 0.10$  indicating this coefficient is not statistically significant in determining the price paid for Angus bulls. The sign associated with the coefficient for YWEPD is not as hypothesized. In Equation 1 and Equation 2 the sign for the coefficient associated with YWEPD was positive as was hypothesized. This is an unexpected change as a higher value would indicate more pounds of weight associated with a yearling calf.

The coefficient for Calving Ease Maternal EPD is -2.38 suggesting that as the percentage increases the price will decrease by \$2.38. The P-value is  $\geq 0.10$  indicating this coefficient is not statistically significant in determining the price paid for Angus bulls. The sign associated with the coefficient for MCE is not as hypothesized. As this is a measure of the ease of calving associated with the sire's grand progeny the fact that it is not

statistically significant is not surprising. The negative sign is not as expected as the value increases the number of assisted births would decrease.

The coefficient for Maternal Milk EPD is -2.27 suggesting that for each unit of increase the price will decrease by \$2.27 per head. The P-value is  $\geq 0.10$  indicating this coefficient is not statistically significant in determining the price paid for Angus bulls. The sign associated with the coefficient for MM is negative in Model 3. We were unsure as to the sign because the EPD can be interpreted differently by producers. While this variable is not statistically significant in determining the final price paid for Angus bulls it appears that the extra growth associated with a higher MM EPD in this equation is discounted. This could be due to the extra nutritional demands that a higher MM EPD would require of dams sired by a bull with a high MM EPD.

The coefficient for Marbling EPD is 11.21 suggesting that for each increase in percentage of marbling the price will increase by \$11.21. The P-value is  $\geq 0.10$  indicating this coefficient is not statistically significant in determining the price paid for Angus bulls. The sign associated with the coefficient for Marbling EPD is positive as was hypothesized.

The coefficient for Ribeye Area EPD is 665.58, suggesting that for each one square inch increase the price will increase by \$665.58. The P-value is  $\leq 0.10$  indicating that this coefficient is significant from zero and we can be 90% certain that this variable is a determinate of final price for Angus bulls sold. The sign associated with the REAEPD is positive as was hypothesized. In Equation 1 the ultrasound Ribeye area was of statistical significance but ceased to be in Equations 2 and 3. Equation 3 had the addition of the Ribeye Area EPD which is indicative of the degree of muscling in a carcass. In the third



equation this is the only statistically significant EPD. This would seem to indicate that producer's place a value on the degree of muscle that can be imparted in future progeny.

The coefficient for Fat EPD is 3005.06, suggesting that for each inch of external carcass fat the price will increase by \$3005.06. The P-value is  $\geq 0.10$  indicating this coefficient is not statistically significant in determining the price paid for Angus bulls. The sign on the coefficient associated with FAT EPD is not as hypothesized. A negative sign was hypothesized due to the fact that a carcass that has excessive condition can be subject to discounts due to the increased amount of trim associated with the carcass. A certain degree of condition is needed to achieve a desirable quality grade but should not account for the positive sign as the Marbling EPD would be a more likely value to anticipate the quality grade of a carcass.

### **5.5 Result Comparison:**

Comparing the changes between Equation 2 and Equation 3 some of the independent variables that were significant at a minimum of the  $P \leq 0.10$  level became statistically insignificant having a P value  $\geq 0.10$  therefore not being price determinants for the final price paid for Angus bulls. Those independent variables that changed were: YR2009, YR2010 and CEEPD. The P value associated with the independent variable TestWt did change between the two models but remained a statistically significant price determinant as the P values changed from being significant at the  $P \leq 0.10$  level to being significant at the  $P \leq 0.05$  level have a P value in model 3 of  $P = 0.0107$ .

## CHAPTER VI: CONCLUSION

This study evaluated data compiled from the Oklahoma Panhandle State University Bull Test and Sale over a six year period encompassing the years 2008-2013. The intended purpose of the study was to try to discover what information or traits buyers were utilizing in their selection of potential herd sires.

Based upon the reviewed literature the use of regression analysis to create a hedonic model was determined to be an appropriate method to analyze the data. Three different models were developed starting with a model with data from the 128 day testing period with a dummy variable indicating if the bull had an EPD profile in the sale catalog. The second model built upon the first by removing the binary EPD value and replacing it with performance and maternal EPD values associated with the individual bulls. The third model expanded the second model by including EPDs related to carcass attributes.

Model one results had the majority of the variables being statistically significant at a 0.10 level. The variables that were not significant were: Weight per Day of Age, Scrotal circumference, Frame score and the binary variable for having an EPD profile in the sale catalog. The model had an adjusted r squared value of 0.4636 indicating that the data was a good fit.

Model two expanded on Model one by including the following EPDs: Calving Ease Direct, Birth Weight, Weaning Weight, Yearling Weight, Calving Ease Maternal and Maternal Milk. The inclusion of the new values resulted in the following variables being statistically significant: The dummy variables for all years except 2008, birth weight (actual), final test weight, average daily gain and calving ease direct EPD. The model has an adjusted R squared value of 0.4761 which is higher than the value associated with Model one. This would indicate that the inclusion of actual EPDs makes the model a better

fit for the data while we have to keep in mind that the sample number declined as not all bulls in the data set for the first model had complete EPD profiles.

The final model has the smallest sample set as it includes the most EPDs. Additionally all the bulls from 2008 were removed as none of the bulls sold that year had complete carcass EPDs presented to buyers on the sale day. The additional EPDs that were included into Model three were: Marbling EPD, Ribeye Area EPD and Fat EPD. After Model three was run, the following variables were significant at the 0.10 level at least: Year 2011, Year 2012, birth weight, final test weight, average daily gain and calving ease direct EPD. The adjusted r squared value for Model three is 0.4313 which is the lowest of all three models.

The following variables were statistically significant in all three models: Year 2011, Year 2012, birth weight, final test weight and average daily gain. Both of the years variables stayed significant at the 0.01 level across all three models. The bulls' actual birth weight and average daily gain also stayed significant across all three models at the 0.01 level. The final test weight variable while it was statistically significant across all models at the 0.10 level or better, its p-value increased in each model estimated.

The age and age squared variables were only significant in Model one. The age variables were included in all of the models but decreased in significance. Additionally, the ribeye ultrasound variable was significant in Model one but not in either of the subsequent models. The calving ease direct EPD while included in both Model two and Model three was only significant in the first model it was included in.

The findings for age and age squared were similar to what Dhuyvetter et al. (1996) study yielded in that buyers would pay a premium for older bulls but that the premium

decreased as the bull's age increased. This was due to the fact that at a certain point a buyer placed less of a premium on an increase in age. While our age and age squared variables were significant in the first model they were no longer significant in the other two models. This could be due to the fact that the bulls final test weight was provided to the buyers. As final test weight is a function of age and traditionally weight is construed as an indicator of age buyers could have shifted their emphasis to the final test weight. The final test weight was significant across all three models at the 0.01 level.

Birth weight was significant across all three of the models at the 0.01 while the birth weight EPD which was included in models two and three was not statistically significant in either model. This runs contrary to what Jones et al. and Brimlow and Doyle (2014) reported.

The inclusion of the ribeye EPD in Model three resulted in findings similar to Jones et al. (2008) that while buyers had access to an ultrasound value for each bull, the ribeye EPD was significant. We are unsure why in Model two the ribeye ultrasound variable become statistically insignificant when there was not a genetic counterpart involved in the equation.

Brimlow and Doyle (2014) created a value to represent genetic growth potential which they referred to as the birth-to-yearling EPD. We included the weight per day of age for each of the bulls in all three models. The birth-to-yearling EPD was significant for Brimlow and Doyle (2014) and also had the highest estimated coefficient. The weight per day of age variable was not significant in any of the three models. This was surprising to us as we anecdotally believed that buyers at the OPSU Bull Test Sale placed significant emphasis on the value.

It would appear based on the three models estimated that the buyers at the OPSU Bull Test Sale that buyers who purchase bulls at the sale place most of their emphasis on physical production measures. This is based on the fact that actual birth weight, average daily gain and final test weight were significant across all three models. While in models one and three there was the evidence that buyers will use ribeye data it is hard to say which is favored due to the fact that in Model two the ultrasound data was not significant even though there was no alternative variable. This is similar to what Chvosta et al. (2001) discussed in their research where they determined that SPMs were utilized more selection was made within a herd and EPDs were used more comparing herds.

We do recognize that there are other variables that could be included into the model and further researched. The reputation of the seller could be explored as the OPSU bull test is open to any producer that wishes to nominate bulls. Some producers have been long time consigners and have a reputation associated with the bulls they have previously sold while some consigners are newcomers to the OPSU bull test and sale. The pedigree of the bulls offered for sale could be included to measure if any specific sire lines are utilized in the selection criteria of buyers. Sale order can influence the price paid for a bull and at the OPSU bull test sale the bulls are sold in order based on the index value created at the completion of the testing period. The first bull sold is the high indexing senior bull from the sale and alternates between junior division bulls and senior division bulls based on their index value in a declining order.

An area of future work could be to look at the buyers at the OPSU bull test sale. The buyers could be looked at in terms of if they are repeat buyers, how many bulls they typically purchased at each sale, a description of their operation type and their motivation

for purchasing sires at this particular sale. Additionally, the disposition of the bulls could be introduced into a model to explore any influence on the final price paid by a producer.

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## APPENDIX A-CORRELATION MATRIX MODEL 1

	<i>age in days</i>	<i>age in days squared</i>	<i>Yr2008</i>	<i>Yr2009</i>	<i>Yr2010</i>	<i>Yr 2011</i>	<i>Yr2012</i>	<i>Birth Weight (BW)</i>	<i>Final Test Weight</i>	<i>Average Daily Gain (ADG)</i>	<i>Weight per day of age (WDA)</i>	<i>Ribeye Area (Actual)</i>	<i>Scrotal Size (cm)</i>	<i>adj. 365 Frame Score</i>	<i>Epd in catalog</i>	<i>Price</i>
age in days	1															
age in days squared	1.00	1.00														
Yr2008	-0.08	-0.08	1.00													
Yr2009	-0.06	-0.07	-0.20	1.00												
Yr2010	0.04	0.04	-0.21	-0.20	1.00											
Yr 2011	0.01	0.01	-0.22	-0.21	-0.21	1.00										
Yr2012	0.02	0.02	-0.21	-0.20	-0.21	-0.21	1.00									
Birth Weight (BW)	-0.17	-0.18	0.05	-0.08	-0.06	0.04	0.01	1.00								
Final Test Weight	0.72	0.72	-0.01	0.11	0.08	-0.13	-0.18	0.03	1.00							
Average Daily Gain (ADG)	0.21	0.21	-0.02	0.21	0.03	-0.15	-0.31	0.02	0.61	1.00						
Weight per day of age (WDA)	-0.04	-0.05	-0.01	0.00	-0.02	-0.05	0.08	-0.02	-0.06	-0.05	1.00					
Ribeye Area (Actual)	0.00	0.00	0.40	0.14	-0.25	-0.27	-0.15	0.14	0.31	0.21	-0.04	1.00				
Scrotal Size (cm)	0.28	0.28	-0.14	0.03	0.17	-0.01	-0.05	-0.01	0.37	0.17	-0.01	0.05	1.00			
adj. 365 Frame Score	-0.05	-0.05	-0.05	0.10	0.06	0.03	-0.10	0.22	0.25	0.14	0.00	-0.03	0.14	1.00		
Epd in catalog	0.10	0.09	-0.04	0.06	0.01	-0.04	0.06	0.04	0.04	0.04	-0.01	-0.02	0.02	-0.08	1.00	
Price	0.32	0.31	-0.08	-0.16	-0.21	0.18	0.11	-0.11	0.44	0.41	-0.01	0.12	0.15	0.11	0.03	1.00



## APPENDIX B—CORRELATION MATRIX MODEL 2

	<i>age in days</i>	<i>age in days<sup>2</sup></i>	2008	2009	2010	2011	2012	<i>Birth Wgt (BW)</i>	<i>Final Test Wgt</i>	<i>Avg. Daily Gain (ADG)</i>	<i>Wgt /day of age (WDA)</i>	<i>Ribeye Area (Act)</i>	<i>Scrotal Size (cm)</i>	<i>adj. 365 Frame Score</i>	<i>Price</i>	<i>CE</i>	<i>BW</i>	<i>WW</i>	<i>YW</i>	<i>MCE</i>	<i>MM</i>	
age in days	1.00																					
age in days <sup>2</sup>	1.00	1.00																				
2008	-0.16	-0.16	1.00																			
2009	-0.08	-0.08	-0.11	1.00																		
2010	0.05	0.05	-0.12	-0.24	1.00																	
2011	0.03	0.02	-0.12	-0.24	-0.27	1.00																
2012	0.02	0.03	-0.11	-0.22	-0.24	-0.25	1.00															
Birth Wght (BW)	-0.19	-0.19	0.09	-0.12	-0.07	0.01	0.09	1.00														
Final Test Weight	0.72	0.72	-0.12	0.05	0.13	-0.14	-0.14	0.05	1.00													
Avg. Daily Gain (ADG)	0.21	0.20	-0.10	0.19	0.05	-0.16	-0.29	0.00	0.60	1.00												
Wgt/ day of age (WDA)	-0.03	-0.04	0.00	-0.01	-0.02	-0.05	0.10	-0.03	-0.07	-0.07	1.00											
Ribeye Area (Act.)	-0.08	-0.08	0.25	0.22	-0.23	-0.25	-0.07	0.21	0.26	0.20	-0.05	1.00										
Scrotal Size (cm)	0.24	0.24	-0.08	-0.07	0.19	-0.02	-0.05	0.01	0.32	0.14	-0.02	0.04	1.00									
adj. 365 Frame Score	-0.06	-0.05	-0.02	-0.02	0.12	0.05	-0.12	0.23	0.23	0.11	-0.02	0.03	0.10	1.00								
Price	0.29	0.29	-0.09	-0.23	-0.24	0.22	0.14	-0.08	0.38	0.36	-0.02	0.10	0.07	0.05	1.00							
CE	-0.01	-0.01	-0.09	0.01	-0.04	-0.03	0.06	-0.14	0.01	0.11	0.02	0.04	0.04	-0.19	0.26	1.00						
BW	0.13	0.13	-0.04	0.05	0.18	-0.06	-0.09	0.11	0.14	-0.01	-0.03	-0.11	0.05	0.21	-0.23	-0.74	1.00					
WW	0.03	0.04	-0.27	-0.25	-0.08	0.02	0.18	0.06	0.09	0.11	0.04	-0.06	0.12	-0.01	0.24	0.24	-0.04	1.00				
YW	0.10	0.10	-0.30	-0.21	-0.01	-0.05	0.16	-0.04	0.17	0.21	0.05	-0.07	0.17	-0.04	0.28	0.36	-0.12	0.88	1.00			
MCE	0.11	0.10	-0.57	0.08	-0.10	0.02	0.09	-0.12	0.06	0.11	-0.01	-0.06	0.02	-0.15	0.19	0.59	-0.39	0.32	0.41	1.00		
MM	0.21	0.20	-0.48	-0.03	-0.05	0.02	0.09	-0.09	0.20	0.24	0.00	-0.12	0.10	-0.03	0.25	0.27	-0.17	0.39	0.45	0.39	1.00	

### APPENDIX C-CORRELATION MATRIX MODEL 3

	<i>age in days</i>	<i>age in days squared</i>	2009	2010	2011	2012	<i>Birth Wgt (BW)</i>	<i>Final Test Wgt</i>	<i>Avg Daily Gain (ADG)</i>	<i>Wgt/day of age (WDA)</i>	<i>Ribeye Area (Act)</i>	<i>Scrotal Size (cm)</i>	<i>adj. 365 Frame Score</i>	<i>Price</i>	<i>CE</i>	<i>BW</i>	<i>WW</i>	<i>YW</i>	<i>MCE</i>	<i>MM</i>	<i>Marb</i>	<i>RE</i>	<i>Fat</i>	
age in days	1.00																							
age in days <sup>2</sup>	1.00	1.00																						
2009	-0.10	-0.09	1.00																					
2010	0.10	0.10	-0.15	1.00																				
2011	-0.02	-0.02	-0.09	-0.30	1.00																			
2012	-0.10	-0.10	-0.12	-0.39	-0.25	1.00																		
Birth Wgt (BW)	-0.30	-0.29	-0.04	-0.11	0.11	0.04	1.00																	
Final Test Wgt	0.75	0.75	-0.05	0.19	-0.10	-0.27	-0.03	1.00																
Avg. Daily Gain (ADG)	0.20	0.19	0.05	0.08	-0.22	-0.32	-0.01	0.56	1.00															
Wgt/day of age (WDA)	0.00	-0.01	-0.01	-0.05	-0.04	0.12	-0.08	-0.12	-0.12	1.00														
Ribeye Area (Actual)	-0.11	-0.10	0.10	-0.23	-0.12	-0.07	0.18	0.17	0.13	-0.10	1.00													
Scrotal Size (cm)	0.43	0.44	-0.19	0.29	0.04	-0.20	-0.04	0.50	0.15	-0.05	-0.05	1.00												
adj. 365 Frame Score	-0.05	-0.05	-0.11	0.14	0.07	-0.13	0.32	0.23	0.08	-0.04	0.05	0.18	1.00											
Price	0.16	0.16	-0.12	-0.32	0.10	0.15	-0.14	0.31	0.39	-0.02	0.18	0.09	0.02	1.00										
CE	0.03	0.02	0.07	-0.12	-0.05	0.01	-0.17	0.04	0.17	0.01	0.03	-0.03	-0.27	0.29	1.00									
BW	0.12	0.12	-0.09	0.25	-0.05	-0.07	0.16	0.13	-0.09	-0.03	-0.11	0.13	0.22	-0.27	-0.74	1.00								
WW	0.04	0.04	-0.06	-0.30	-0.05	0.14	0.14	0.10	0.05	0.04	0.08	0.07	-0.02	0.17	0.12	0.01	1.00							
YW	0.14	0.14	-0.04	-0.23	-0.13	0.09	0.02	0.21	0.20	0.05	0.03	0.11	-0.06	0.23	0.25	-0.07	0.82	1.00						
MCE	0.06	0.06	0.06	-0.31	0.00	0.01	-0.10	0.02	0.09	-0.02	0.14	-0.12	-0.25	0.22	0.69	-0.52	0.18	0.27	1.00					
MM	0.23	0.23	0.01	-0.26	-0.13	0.01	0.00	0.27	0.39	0.00	-0.05	0.01	0.01	0.26	0.21	-0.18	0.34	0.45	0.19	1.00				
Marb	0.14	0.15	-0.02	-0.07	-0.03	-0.04	-0.06	0.11	0.00	-0.01	0.01	-0.05	-0.04	0.09	0.08	-0.08	0.13	0.13	0.05	0.07	1.00			
RE	-0.03	-0.03	-0.04	-0.40	-0.13	0.08	0.08	0.01	0.11	0.03	0.36	-0.19	-0.13	0.26	0.21	-0.23	0.34	0.35	0.21	0.33	0.09	1.00		
Fat	0.13	0.13	-0.07	0.03	0.03	-0.19	-0.05	0.12	0.10	-0.05	-0.12	0.01	-0.07	0.04	-0.02	-0.03	0.12	0.13	0.12	0.13	0.10	0.02	1.00	