FACTORS INFLUENCING THE PRICE OF VALUE-ADDED CALVES AT SUPERIOR LIVESTOCK AUCTION

by

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Abstract

Value-added management at the cow-calf level is integrated across breeding, health and nutrition programs. Hedonic pricing models are necessary to navigate through the layered management standards imposed by certified health and marketing programs on the cow-calf sector. Previous research in feeder calf pricing models provides insight on the use and development of ordinary least squares in estimating price effects. Breed, vaccination program, age-and-source verification and natural-beef production have become more relevant as vertical coordination has influenced commercial cow-calf producers. This study provides the industry with new information pertaining to the revenue opportunities that exist for cow-calf producers through increased coordination in the beef industry.

Video and satellite auction markets are recognized as a national pricing mechanism for feeder cattle in the United States. These markets represent the management and marketing practices of national cow-calf producers and the tastes and preferences of a national stocker and feedlot industry. Previous research in feeder cattle pricing models is applied to the current genetic, management, marketing and market structure information from video auction markets to discover relevant price effects pertaining to value-added calf production.

More intensive value-added management practices were expected to enhance the revenue of cow-calf producers selling their calves through video auction markets. This research confirms that verified health and genetic claims produce higher calf prices compared to commodity calves. Weaned calves with at least two rounds of respiratory vaccinations generated an additional $5.50 to $7.50 per cwt., and weaning created $2.75 to $4.50 per cwt. in premiums over non-certified health programs. There were statistical differences among the premiums for each aggregated breed influence, and Angus and black and black-white faced cattle offered the highest breed premiums at $5.25 to $7.50 per cwt. compared to Brahman-influenced calves. Age-and-source verification presents the best opportunity for video auction market premiums among recently developed marketing programs. Statistically significant premiums ranged from $1.25 to $2.00 per cwt. for both steers and heifers over the last five years.

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Dedication

There were never a shortage of lessons to be learned growing up on the farm. Maybe that is why I have enjoyed school. The best teachers I ever had were my parents and grandparents who were never far away growing up in a small western Kansas town. I dedicate my thesis and graduate school experience to them. They provided me with the support and life lessons to achieve all my goals. I especially want to dedicate this thesis to the three farmers who shaped my life the most – my father Loran Zimmerman, grandfather Norbert Leiker and great grandfather Albinus Munch. Thanks to you some of my best memories always involve the family farm.

CHAPTER 1 - Introduction

Cow-calf producers represent the foundation for beef production. Advancements in science and technology have led to herd management practices that produce calves to meet the production preferences of stockers, backgrounders and feedlots, as well as the tastes of discerning restaurateurs and beef consumers. Increased levels of vertical coordination throughout the beef industry have created price signals for specific calf traits at the ranch level. Careful investment in genetic, health and nutrition management programs are necessary to meet evolving industry expectations.

The benefits of specific calf attributes to stockers, feedlots, packers and consumers are signaled through market premiums to cow-calf producers. Hedonic price analysis can be used to properly identify implicit market prices for lot, genetic, management and marketing characteristics. However, existing research rarely quantifies market incentives for specific calf management strategies on a national level. Published research frequently focuses on local and regional market data and does not discuss the effect of vertical coordination in the cow-calf sector. Value-added management at the cow-calf level is integrated across breeding, health and nutrition programs. Feeder calf price research needs to accurately model the individual price effects of these bundled management approaches to prevent misleading and false estimates. Average sale prices based on individual lot characteristics cannot account for the isolated effect of one management practice. Hedonic pricing models are necessary to navigate through the layered management standards imposed by certified health and beef marketing programs on the cow-calf sector. Existing research point to the challenge in finding accurate pricing data that can reflect the variety of marketing and management opportunities available to U.S. cow-calf producers.

This study meets that challenge by quantifying the marginal effect of value-added production on calf prices at Superior Livestock Auction (SLA) video market auctions. Data available for this study includes lot characteristics and sale prices for calves sold from 1995 to 2009. Comparing SLA video market data to larger industry trends will illustrate how sale prices, premiums and discounts vary across seasons. The long-run nature of the database will also explain how prices change as domestic and export market requirements influence production at the cow-calf level. The study also evaluates how market dynamics affecting calf buyers translate to average price changes by incorporating corn and feeder cattle futures prices into the calf price model.

1.1 Objectives

This research analyzes the market incentives available to cow-calf producers who enhance calf management and marketing through value-added production systems. Ordinary least squares (OLS) regression analysis will determine how incremental management in the cow-calf sector influences marginal sale prices.

The study will focus on the following objectives:

1. Review the existing literature on feeder cattle price hedonics to develop a model suitable for analyzing SLA video market sales.
2. Quantify the influence of lot, genetic, management, and marketing characteristics, as well as market conditions on sales price, including but not limited to lot size, weight variation, frame size, breed, health program, implant protocol, natural-market eligibility, age-and-source verification (ASV), state of origin and feeder cattle futures contract prices.
3. Discuss how evolving domestic and export market programs influence price determinants in the calf market over time.

Based on the literature review, it is predicted that calves raised and marketed under more intensive, goal-oriented management programs will receive a higher sale price through the SLA video market than more commodity calves. Producers who utilize intensive management programs with verified genetic and health claims will receive higher calf prices than those with commodity calves, which do not possess characteristics associated with more advanced herd management programs.

1.2 Project Description

A large, detailed auction market database, such as the one available for this research, allows for hedonic regression analysis to quantify market incentives and discounts for calves managed to specific management and market endpoints. The result will be a series of econometric models that explain the variation in calf prices over time and across sale lots. The lot sale price will be compared to the general lot, genetic, management and marketing information available for each lot of cattle sold. Information on futures contract prices for feeder cattle and corn will be included to compare how these dynamics affect calf prices. The analysis will determine the statistical significance and economic difference of premiums and discounts associated with each lot characteristic. A discussion about the effect of beef export markets, branded beef programs and Choice-Select spreads at sale time will provide inferences for how high-quality beef markets and international trade affect value-added calf prices.

1.3 Benefit to the Industry

Livestock auction markets continue to be an important resource for marketing calves at the cow-calf level. According to a 2007 survey of cow-calf producers coordinated by the National Animal Health Monitoring System, more than 50 percent of U.S. cow-calf producers depend on auction markets as their primary marketing method for weaned steers and older heifers. The survey found 61 percent of cow-calf producers depend on auction markets to sell weaned steer calves. An additional one percent of cow-calf producers sell weaned steers through video or Internet auctions (USDA 2010). The number of producers participating in video market auctions is relatively small. However, the market behavior of buyers and sellers in a national livestock video market provides valuable calf pricing information for cow-calf producer using auctions as calf marketing tool. The sustainability of high-quality beef production depends on the cow-calf sector's ability to receive a premium for managing and marketing value-added calves. The size and scope of the SLA database compiled over the last 15 years by Pfizer Animal Health can provide cow-calf producers with a robust model for quantifying auction market incentives based on lot characteristics.

The rigorous statistical and economic analysis of the SLA database presented in the following research provides the beef industry and academic community with practical marketing information on the influence of specific lot, genetic, management and marketing characteristics on calf prices. The regression analysis results will reveal how individual traits marginally influence average sale price and quantify the how traits work together in determining price. Cow-calf producers can use this information to increase revenues while meeting buyer preferences.

1.4 Considerations for Evaluating Video Auction Market Data

There are notable structural differences between video and traditional auction markets. These disparities need to be clearly understood while analyzing the results of video market hedonic pricing studies. Bailey et al. (1991) summarized why SLA has become a widely accepted pricing mechanism in the beef industry:

> "Sellers will want to use video cattle auctions if they provide relatively high prices and a reliable market. Economic theory suggests that video auction prices may indeed be higher than traditional auction prices. Satellite video auctions reduce travel time and expense for buyers who can bid from remote locations. Video cattle auctions can also reduce buyers' search time since they can offer a large number of

> cattle quickly. For example, SLA offered over 90,000 cattle for sale during a two-day auction in 1988 (Scharlier). Using video auctions reduces health problems because cattle are not mingled with those from other lots and are transported to only one destination." (p. 465)

In 2004, Gillespie et al. provided additional insight on the role of video auction markets as a pricing mechanism for cow-calf producers.

> "Advantages of this method relative to conventional auction are:
>
> (a) a larger number of buyers generally bid on the animals, thereby increasing competition (Bailey and Peterson 1991);
>
> (b) buyers who purchase via video auction are typically interested in specific animal traits;
>
> (c) commission fees are typically lower; and
>
> (d) since animals remain on the farm or ranch the seller can "no sale" if offers are inadequate and shrinkage is minimal.
>
> However, the larger volumes tend to attract buyers searching for larger quantities of consistent-quality animals. If these buyers' preferences are based upon feedlot operator preferences (as well as packer preferences), then pricing efficiency has been gained." (p. 151)

Based on these observations, estimates from video auction data should be considered distinct from price signals discovered in local auction markets. Video auctions signal cattle market conditions on a much larger scale than traditional auctions by representing national buyers and sellers in one setting. Video auctions provide buyers specialized benefits – the convenience and reduced health risk of preassembled truckload lots of cattle; farm-fresh calves not exposed to the stress of local auction markets; cattle representing a variety of U.S. locations, climate conditions and management programs; and detailed information concerning breeding, nutrition and health programs. Sellers also benefit from utilizing video auction markets – reduced transportation and shrink, exposure to buyers with a variety of purchase preferences, marketing tools and advice offered through the video market representatives, risk management through forward contracting, and the avoidance of weather-related marketing issues. Catalog and on-screen information benefits all market participants by creating a higher level of transparency and reducing the risk of asymmetric information.

1.5 Organization of Thesis

The thesis is divided into seven chapters. Chapter 2 includes a review of pertinent research in the field of feeder calf prices. Organization within this chapter includes a historical perspective on hedonic price models with special attention given to feeder calf hedonics and summarized results from those studies based on the shared characteristics evaluated in this research project. A summary of the theoretical understanding used in developing the empirical research model is presented in Chapter 3. A description of the data, model specifications, and methods and procedures used in the analysis is highlighted in Chapter 4. The empirical results of the study's models will be presented in Chapter 5. Inferences that can be gained from the study and applied to future studies are in Chapter 6. Finally, Chapter 7 will provide final conclusions about the research and suggestions for future improvements.

Table 1.1- Common Thesis Report Abbreviations

Abbreviation	**Description**
lbs.	Pounds
cwt.	Hundredweight
USDA	U.S. Department of Agriculture
SLA	Superior Livestock Auction
OLS	Ordinary least squares
Natural	Natural-market eligible cattle
NHTC	Non-Hormone Treated Cattle market eligible
ASV	Age-and-source verification
PVP	Process Verified Program
RFID	Radio-frequency identification tag
IBR	Infectious bovine rhinotracheitis
BVD	Bovine viral diarrhea virus
PI3	Parainfluenza type 3
Lepto	Leptospirosis
BRSV	Bovine respiratory syncytial virus
Bangs	Brucellosis
Pinkeye	Moraxella bovis - associated with infectious bovine keratoconjunctivitis
H. somni	*Haemophilus somni* bacterial disease
BVD-PI negative	Negative test result for being persistently infected with bovine viral diarrhea virus
VAC	Value-added calf health protocol
VAC 24	Superior Livestock Value Added Calf 24 Protocol
VAC 34	Superior Livestock Value Added Calf 34 Protocol
VAC 34+	Superior Livestock Value Added Calf 34+ Protocol
VAC 45	Superior Livestock Value Added Calf 45 Protocol
VAC Precon	Superior Livestock Value Added Calf Precon Protocol

CHAPTER 2 - Literature Review

The use of hedonic modeling to estimate prices for quality attributes in agricultural commodities is well documented in economic and production-science literature. Economists developed and used this technique for estimating marginal implicit prices beginning in the early 1900s. Theoretical implications of this research approach can be better understood through early hedonic models that estimated the effect of product traits on implicit agricultural commodity prices. A review of current research on price determinants in feeder calf markets provides the foundation for models utilized in this study and offers contemporary data for comparison purposes.

2.1 Historical Studies Related to Hedonic Pricing Models

Studies evaluating the factors that influenced agricultural commodities prices were prominent at American Farm Economic Association annual meetings throughout the 1920s. Early studies focused on factors that influenced day-to-day or seasonal price differences in commodity markets. Few studies focused on how quality differences among goods influence price variation in agricultural commodities until 1928 when Frederick V. Waugh presented his paper "Quality Factors Influencing Vegetable Prices."

Waugh's research was based on the belief that producers could increase revenue by selling a quantity, variety and type of crop that buyers desired. His study went beyond assigning value through consumer-demand surveys. Waugh statistically estimated the contribution of product attributes to the prices of asparagus, tomatoes and cucumbers by using sale records compiled at Boston wholesale producer markets. He argued that measuring the quantitative effect of quality factors on price could be more dependable than survey techniques. Consumers may prefer to buy products of average or inferior quality at a lower price, and Waugh argued that products demanded the most do not always embody traits that elicit the highest market price. The motivation for the research project has been used to justify many of the hedonic modeling approaches studied today:

> "If it can be demonstrated that there is a premium for certain qualities and types of products, and if that premium is more than large enough to pay the increased cost of growing a superior product, the individual can and will adapt his production and marketing policies to the market demand. In most cases, he will be able to take advantage of the results of this type of study better than those of a study which explains the relation of prices to acreage or total production. The individual farmer cannot control the size of the crop which will compete with his. He can control to some extent the quality of the commodities he produces." (Waugh 1928, p. 187)

Using a multiple correlation approach, Waugh noted the vegetable characteristics that commanded the highest premiums. For instance, green color, stalk size and uniformity in size accounted for 58 percent of the price variation in asparagus. The amount of green color in the stalk influenced price the most. Green color accounted for 41 percent of asparagus price variation and commanded $0.38 more per dozen bunches with each additional inch of green stalk in the bunch. The research provided simple production and packaging recommendations to improve the prices received in Boston-area markets for each vegetable. Waugh also provided researchers with questions related to cost of production that would need to be addressed to determine overall profitability.

Following Waugh's research, economists applied the principles of hedonic analysis to a variety of products. Sartwelle (1994) as well as Ladd and Martin (1976) highlighted a number of agricultural studies to provide a historical perspective for using hedonic pricing models. In 1961, Griliches used a hedonic model to show that automobile price increases from 1937 to 1960 were attributed to quality improvements. Fettig (1963) evaluated farm tractor prices using statistical analysis and found that tractor horsepower and fuel type linearly accounted for price variation. A 1970 study by Hyslop estimated hard red spring wheat price using a linear combination of percent dockage, protein content, test weight, percent damaged kernels, percent foreign material, percent of shrunken and broken kernels, area of origin, destination and transport mode. Many economists applied hedonic modeling to studies focused on wage with respect to employee characteristics. Wachtel and Betsey (1972) discovered an employee's years of experience in the present job, race, age, sex, years of education and marital status were linearly related to wage rates. These studies each added new perspectives on application of hedonic modeling and its ability to determine the implicit prices of quality attributes.

Nearly 50 years of research in hedonic modeling had evolved when Ladd and Martin published "Prices and Demands for Input Characteristics" in 1976. The paper added to previous hedonic modeling research by outlining two useful theoretical concepts. The first concept said an input's price equals the sum value of the input's characteristics to the producer. In other words, the usefulness of any input in production is dictated by its useful characteristics. The market values of those characteristics represent the marginal production increase that can be attributed to those traits. Therefore, the price paid for an input is the sum of the marginal production values for each characteristic in the product. Ladd and Martin's second concept said the characteristics of an input influence its demand. Their study examines this concept by applying linear programming to the corn-grading system. The goal of the program was to maximize profits by producing corn with an optimal combination of quality attributes.

The study's theoretical arguments begin with a neoclassical firm theory variation that focused on the role of input characteristics in production. In this framework, the production function is dependent on input qualities and each coefficient represents an input's contribution to production. Ladd and Martin (1976) derived the firm's profit function based on this framework and used first order conditions of the function to determine the hedonic pricing model. The use of the production function to derive the marginal value of each input characteristic is an important concept to hedonic modeling. It shows the value of an input is not assigned arbitrarily. The market value of an input characteristic is determined by its productivity.

Hedonic price models also have consumer pricing implications, which show how consumer preferences move through the supply chain to influence farm-level production. "A New Approach to Consumer Theory" by Kelvin Lancaster (1966) provided the foundational argument for using hedonic price models to understand consumer price theory. The approach presented in the paper is summarized in Lancaster's description of the approach:

> "The essence of the new approach can be summarized as follows, each assumption representing a break with tradition:
>
> 1) The good, per se, does not give utility to the consumer; it possesses characteristics, and these characteristics give rise to utility.
>
> 2) In general, a good will possess more than one characteristic, and many characteristics will be shared by more than one good.
>
> 3) Goods in combination may possess characteristics different from those pertaining to the goods separately." (Lancaster 1966, p. 134)

Lancaster asserted "consumer choice arises in the choice between collections of characteristics only, not the allocation of characteristics to the goods" (Lancaster 1966, p. 134). Economists were already exploring detailed concepts related to the first assumption. However, few studies focused on his second and third points, and no published research pulled all three aspects of multidimensional utility into one paper. The study showed multiple-characteristic analyses were the only way to understand and implement the intrinsic qualities of a good into choice modeling. To support his assumptions, Lancaster highlighted the purchasing decision of either a red or grey Chevrolet car. Existing economic theory said the two cars either needed to be considered the same commodity or different commodities. The first theoretical approach ignores the relevant aspect of choice, and the second provides no priori presumption the goods are close substitutes. Using a multiple-trait approach, goods can be evaluated with separate levels of satisfaction, differing only by only one trait. It is an approach that Lancaster says is more similar to how consumers make choices in real life.

Ladd and Suvannunt (1976) blended Lancaster's principles with the modeling approach discussed earlier from Ladd and Martin (1976) to estimate consumer good prices based on product characteristics. Nearly fifty years after Waugh's original work, the research focused on the 1928 paper's call for a new "field in the theory of prices" by developing a consumer goods characteristics model. The study showed the price of a good is equal to the sum of the marginal values of the good's characteristics. Then, the marginal value of each characteristic equals the quantity of the characteristic obtained from product consumed multiplied by its marginal implicit price. The research began by examining the utility derived from consuming goods with specific input characteristics. Ladd and Suvannunt argued that product heterogeneity creates utility variation due to different product characteristics.

The utility maximization function provides the base for developing an input-dependent price model for a product. By applying a budget constraint to the utility maximization problem, consumers must decide how much of a good they can consume to maximize utility with a fixed income. Therefore, consumer utility varies as the characteristics of a consumed good change. With utility presented as a function of product characteristics, Ladd and Suvannunt (1976) used first-order conditions to determine the marginal value each trait contributes to the price of the good and the resulting hedonic price function. To test their model in an empirical setting, they estimated prices for 31 retail food items using nutritional content data. Nutrient amounts of food presented a new wrinkle to existing price research. Most prior research on consumer goods pricing involved the effect of observable traits on price. Ladd and Suvannunt wanted to estimate the effect of immeasurable, but not necessarily unnoticeable, traits on the price. Through the analysis they found certain nutrients had statistically significant influences on retail food prices. Nutrients such as food energy and protein contributed positively to the price of a good, while phosphorous and ascorbic acid led to lower marginal price influences.

2.2 Empirical Hedonic Pricing Studies Involving Feeder Cattle and Calves at Regional Auction Markets

Agricultural economists have used hedonic pricing models frequently to estimate prices in feeder cattle auction markets. Studies evaluating how calf characteristics influence prices received at auction markets span decades. These studies have particular application for cow-calf producers who want guidance on management practices that can enhance revenue. Also, feeder cattle pricing research is well suited for interdisciplinary Extension projects among agricultural economists and animal scientists.

W.K. McPherson (1956) had one of the earliest published studies on feeder cattle pricing. The study compared prices from three Florida auction markets with Chicago terminal-market prices from 1949 to 1953. The research objective was twofold: 1) determine the selection criteria for an ideal cattle market, and 2) understand the price discovery mechanisms in the three Florida markets. McPherson examined average sale prices of slaughter-ready steers and heifers based on U.S. Department of Agriculture (USDA) Quality Grades. The study found the Florida auction markets were efficient at assigning value as grade improved among the lower-tiered quality grades. However, as grades improved to USDA Good or better, McPherson determined the markets were not efficient due to the small number of cattle sold at higher quality grades.

Auction markets quickly became a more utilized and efficient source for marketing cattle in the years following McPherson's study. The increased popularity of auction markets provided agricultural economists with more reliable price data. This allowed for more robust studies involving feeder calf price determinants. These trends came to fruition when Williamson et al. (1961) evaluated 9,481 lots of cattle sold in Virginia auction markets from 1951 to 1956. Utilizing least squared means estimation, the study estimated the effect of the following characteristics on the price of steers and heifers: sale size (300 to more than 1500 head), lot size (1 to more than 50), breed (Hereford, Angus, Shorthorn, Hereford-Shorthorn and Hereford-Angus), straightbred or crossbred, average weight, and grade (Medium, Good, and Fancy and Choice).

The research found the price determinants for steers and heifers were notably different based on calf and market characteristics. As sale size increased, steers generally received higher average prices while heifer prices were unaffected. The economists also found an optimal lot size between 21 to 30 head for steers. Price appeared to be unaffected by increasing lot size beyond the optimal range. However, the heifer regression model showed price was positively correlated with increasing lot size. Breed effect was the same regardless of sex, with Angus-influenced calves receiving the highest premiums. Hereford- and Shorthorn-bred calves followed, and straightbred animals brought substantially more than crossbreds. The regression results revealed an optimal weight range of 400 to 500 pounds (lbs.). Calves weighing a hundred pounds on either side of the optimal range received a slightly smaller price, and calves weighing more than 600 lbs. received the highest discounts. Buyers also rewarded cow-calf producers who marketed calves at higher quality grades (Williamson et al. 1961).

These studies, and others like them, were predominant among the Southeast throughout the 1970s. As feedlot expansion reached the Central Plains and Southwest, feeder cattle price modeling reached larger audiences (Sartwelle 1994). Studies organized by researchers in these key cattle feeding regions provided new estimation techniques and focused on traits relevant to cattle feeders and cow-calf producers alike. Studies by James and Farris (1971) and Menzie et al. (1972) have been cited by agricultural economists for their applicable format in estimating price effects within feeder cattle markets.

Research by James and Farris (1971) used order buyer invoice data from 1966 to 1968 and USDA Market News Service monthly average prices from 1964 to 1968 to estimate price effects. The economists developed an OLS regression equation using cattle characteristics, such as weight, grade, market class and breed type, with other characteristics, including market location, lot size and seasonality. The study included new variables that made it notably different from previous work. A weight-squared variable captured the non-linear interaction between price and weight, and dummy variables were created to measure the effect of non-continuous cattle and market traits.

The order buyer data provided marked differences in breed type when compared to market news data. Most order-buyer cattle in the study were English-crossbred calves with a predominant Brahman or dairy influence. Referred to as Okies, and designated by grades of Okie #1, Okie #2 and Okie #3, a higher percentage of English-influence leads to a lower Okie grade number and corresponds directly to USDA feeder cattle grades of Choice, Good and Standard. The prices of these calves served as a base for Market News Service calves, which were predominantly English based. Each dataset was evaluated using a separate regression analysis and comparisons were made between each analysis (James and Farris 1971).

James and Farris (1971) found premiums for English influence, and each grade improvement, from Good to Choice or Standard to Good, provided a 10 to 12 percent price premium. Steers were between 10 to 12 percent higher in price compared to heifers. Seasonality in Okie feeder cattle markets was also noticeable. Calves marketed in the fourth quarter brought about three percent less than calves marketed in the second and third quarters. Differences were similar in the market news data with third- and fourth-quarter cattle receiving a two percent discount to other cattle. The study also found as calf weight increased from 350 to 500 lbs., price declined at a constant rate of three percent per 50-pound increase. Market location had a small influence on price.

The difference was generally less than the transfer cost between the markets. In general, markets with a strong cow-calf presence received lower prices than markets with a high feedlot concentration.

The research provided Southwest producers with valuable information to make breeding and management decisions. The region's cow-calf producers generally use Brahman and dairy breeds to increase hybrid vigor. These crossbred calves usually have higher weaning weights but lower quality grade. Using the James and Farris (1971) research, producers could accurately evaluate these tradeoffs to make more profitable management decisions. Feedlot operators could also use the data to determine the optimal price for a lot of calves based on quality grade and potential feed efficiency.

Research by Menzie et al. (1972) incorporated a similar approach using 1969 data from 47 Arizona auctions to determine how weight, sex, breed, lot size and current fat cattle prices influenced feeder cattle prices. The study included data on 2,941 sale lots with 28,501 cattle. Multiple regression analysis determined a hedonic pricing model similar to James and Farris (1971). The model used dummy variables to estimate price effects for pertinent genetic, management and market characteristic. The study also replicated James and Farris's approach by using a weight-squared term to capture the non-linear weight-price interaction. The economists accounted for a variety of breed effects by including variables for Hereford, Angus, Hereford-Angus cross, Brahman crosses and other crosses.

The research was particularly relevant for using fed cattle futures prices as a proxy variable for external market forces. The study said futures prices could be used "as a method of removing most of the effects of general price level differences for cattle over different time periods." (Menzie et al. 1972, p. 4) Menzie et al. also explained the use of a weight-squared variable in feeder calf pricing models. They realized weight had a negative relationship on price that decreased in magnitude as weight increased. Including a weight-squared variable allowed for a non-constant weight-price relationship to be tested. The economists argued the non-linear relationship had important implications on returns. Since weight influences per head total returns, total returns for calves would not be linear. The study also found a grade increase from low standard to high choice resulted in an $11 per hundredweight (cwt.) premium. Breed had a relatively small influence on price. However, Brahman-cross calves received the highest breed-related premiums generating $0.89 per cwt. more than Herefords. Angus, Hereford-Angus cross and "Okie" cattle were also at a market advantage to Hereford.

The hedonic pricing models established by James and Farris (1971) and Menzie et al. (1972) became the research standard. University researchers utilized regional auction market databases and published their findings in Extension technical bulletins throughout the 1970s. A pricing model for calves sold in Colorado auction markets was published by Madsen and Liu in 1971. Folwell and Rehberg (1976) focused on the price determinants of calves and stockers in eastern Washington. The first articles to highlight the characteristics that influence Midwest feeder cattle prices were published by Michigan State University (Schwab 1975, Schwab and Ritchie 1976 and Schwab and Rister 1978). Also, Kuehn (1979) analyzed the price differences of calves in West Virginia livestock auction markets.

Researchers made adjustments to previous studies by adding and replacing the variables estimated in each hedonic model. In 1980, Buccola recommended a new approach to hedonic modeling that used feedlot breakeven calculations to estimate feeder calf prices. The research objective was to use a long-run regression model to estimate the effect of supply and demand on feeder cattle prices. In the long run, he suggested breakeven prices were important to feeder cattle prices since buyers will not pay more for an animal than the difference between its expected value and its expected feeding costs. Buccola added that cow-calf producers are not likely to accept a price for their calves that is less than per head production costs in the long run.

Feeder calf characteristics are important to this argument since weight, breed, grade, age, sex, frame size and other ranch management practices influence expected fed cattle revenues and production costs. Buccola (1980) argued a dynamic approach to feeder cattle price determinants would be more meaningful than static models built on auction market prices. However, he said results from a dynamic analysis can not accurately measure short-run reservation prices. For instance, the price paid for the calf might represent a price less than the seller's sunk costs if the market allows for a lower purchase price. Likewise, cow-calf producers might receive a calf price that exceeds total production costs during years of high feeder cattle demand.

Buccola (1980) also presented a research model estimating the influence of futures market contract prices for corn and live cattle, annual cattle inventory and soil moisture conditions on feeder calf price rate of change with respect to weight. His argument for a more dynamic approach to feeder cattle price analysis led to a better understanding for the use of futures market contract prices to estimate calf prices.

Marsh (1985) developed a dynamic price regression using distributed lag variables to estimate the effect of expected costs of gains and slaughter prices on the monthly premium-discount relationship between steer calves and yearlings. He used corn futures prices to determine anticipated cost of gains and found calves were more affected by changing expected cost of gains and fed cattle prices than yearlings. A $1 per bushel increase in corn price reduced the price of steer calves $5 per cwt. and yearlings $3.65 per cwt. A similar $1 per cwt. increase in the price of fed cattle increased steer calf prices $1.39 per cwt. and yearlings $1.19 per cwt. The price relationship shows that cattle feeders offset the risk of lightweight cattle with larger price adjustments. The price adjustments also point to perceived differences in returns and feed efficiency for lightweight and heavyweight cattle as they reach slaughter weight. Marsh argued distributed lag variables more clearly model the price influences and infrastructure challenges placed on feedlots. He said corn is often purchased by feedlots on long-term contracts, and longer distributed lags illustrate the length of negotiated contracts. Lag variables improve the modeling of fixed asset allocation within feedlots since it takes time to adjust capacity and production methods as costs of gain increase.

Faminow and Gum (1986) possibly did as well as any researchers to date at summarizing the conflict introduced in Buccola's (1980) work. Their study highlighted the short-term challenges outlined in Buccola's comparative statics framework and the problems associated with linear regression estimations, such James and Farris's 1971 study. The economists suggested a new model with non-linear estimations for price-weight and price-lot size relationships, interaction terms for sex and year with weight, and dummy variables representing time and auction market. Faminow and Gum said the new modeling approach more accurately modeled the price behaviors in feeder cattle auction markets and current market conditions. It also offered the flexibility to plot separate steer and heifer price relationships.

The empirical results from individual feeder calf sales in May 1984 and 1985 supported Faminow and Gum's (1986) theoretical model. A non-linear price-weight relationship was statistically significant for both steers and heifers; however, the shape of each curve differed. The price-weight relationship for steers was convex from below and the relationship for heifers was concave from below. This relationship translates to a more aggressive discount for heifers relative to steers as weight increases. The model is useful for calculating the gross per head value for steers and heifers and the marginal price adjustment for each group of calves as weight increases. The price-lot size relationship also fit the data in a pattern that was concave from below, indicating lot size and lot-size-squared coefficients that were positive and negative, respectively. Based on the shape of the curve, Faminow and Gum determined the optimal lot size was approximately 60 head with a relatively flat response beyond the optimum size. They explained the trend existed since few cattle in their dataset had lot sizes beyond 60 head. The corresponding lot weight would be 32,000 lbs., which related well to a standard semi-trailer-load capacity of 40,000 lbs.

These results stood in contrast to previous research that estimated linear price responses to lot size and weight (James and Farris 1971 and Folwell and Rehburg 1976). The study provided a more substantial link between production and marketing decisions and offered promising implications for future hedonic pricing models to estimate weight and lot size effects in other regions and across seasons. With improved modeling techniques, cow-calf producers could analyze market trends in their area to determine the optimum lot size, weight, time of year and auction market to maximize revenue. The models could also be used to maximize expected total marginal value of additional gain by differentiating management and marketing strategies based on sex, time of year and market location (Faminow and Gum 1986).

The foundation built through previous feeder calf hedonic pricing studies led to continuous model adaptations and the inclusion of new relevant variables. Research from Schroeder et al. (1988) added to the work of previous economists. Using the arguments of Buccola (1980), Marsh (1985) as well as Ladd and Martin (1976), the economists said feeder cattle price differences should reflect the supply and demand of cattle at different weight and grades as well as the value of calf characteristics. The purpose of the study was to estimate the effect of previously studied and new characteristics on Kansas feeder cattle prices. The most notable difference from previous hedonic pricing models was the inclusion of the feeder cattle futures price to account for long-run price variation in the analysis.

Data for the study were collected from the fall and spring run of seven Kansas auction markets. The analysis looked at previously studied variables, including weight, weight-squared, lot size, lot size squared, uniformity, muscling, frame size, breed, time of sale and market location. It also included five additional variables: health, horns, condition, fill and the prior day's feeder cattle futures closing price. Correlation coefficients were evaluated for all physical characteristics to ensure that each variable independently assessed the value of each trait. Recognizing that calf sex and weight influence prices, Schroeder et al. (1988) stratified the data into four separate sex-weight specific regression models: 1) 300 to 599 lbs. steers 2) 600 to 899 lbs. steers, 3) 300 to 599 lbs. heifers, and 4) 600 to 899 lbs. heifers (Schroeder et al. 1988).

Regression results were similar to studies that estimated the same characteristics. Health had the most influence of any new variable introduced in the study. Lot discounts for cattle with physical ailments, mud, or sickness ranged from five to 20 percent of the average price for healthy animals of comparable quality. Horned, fleshy and fat cattle were discounted, and the prices paid for very thin to thin cattle, in general, were not statistically different from cattle of average condition. Buyers also discounted full or tanked cattle, noting a preference to not pay for shrink associated with excessively filled animals. There were also notable differences in premiums across seasons. In the fall, discounts for fleshy cattle declined, while discounts increased statistically for thin and very thin steers. Full cattle also received smaller discounts in the fall relative to the spring. These findings were contrary to Folwell and Rehberg (1976) where the price of eastern Washington feeder cattle was not affected by fleshy or gaunt appearance. Also, the coefficient for feeder cattle future price showed buyers adjust to new market information and bid in the cash market appropriately (Schroeder et al. 1988).

The study revealed previous studies omitted a number of physical characteristics that were relevant to feeder cattle prices. The estimates from these studies could be susceptible to misspecification errors due to the bias imposed by missing variables. The researchers noted separate datasets based on sex and weight also create parameter estimates that are more applicable to the different buying preferences of growers and finishers. Since the published work of Schroeder et al. (1988), there have been more than two dozen studies estimating feeder calf hedonic pricing models. These studies document the changing preferences of feeder calf buyers as benefits in value-added production and improvements in information technology reached the cow-calf sector.

2.2.1 Empirical Hedonic Pricing Studies Involving Value-Added Management in Feeder Cattle and Calf Markets

Sartwelle et al. (1996a) presented the first study estimating feeder cattle prices from two time-series datasets separated by more than a year in time. The economists developed two short-run models on Kansas sales data from 1986-1987 and 1993. In the five years separating each dataset, the economists noted statistically significant differences in the premiums and discounts among many lot characteristics influenced by genetics and management. The researchers noted discounts increased for less desirable traits, such as smaller frame size and lighter muscling. Furthermore, indicators for poor health also led to higher per hundredweight discounts for cattle. Dead hair or mud, stale appearance, sickness, bad eyes, lameness or lumps, and very thin condition led to cattle receiving more severe discounts in the later model. Also, the premiums offered for convenience traits such as larger lot sizes and polled animals increased.

In 2000, Smith et al. developed a study similar to Sartwelle et al. (1996a). The research estimated price premiums and discounts for various individual calf characteristics on 26,608 lots of cattle sold in eastern Oklahoma auction markets in fall 1997 and spring 1999. The study confirmed the price differences attributed to genetics, health and convenience traits found in the previously discussed paper. The 1997 model estimated by Smith et al. showed larger price differences than the 1999 model, but the relative influence of the traits remained similar. This was similar to Sartwelle et al. (1996a), but the Kansas study showed greater price differences in its later model. Sartwelle et al. (1996a) credited the increased price difference to changing long-term fundamentals in feeder cattle pricing. The reversal of this trend in Smith et al. shows that changing long-term fundamentals were possibly not sustained. Each study presented relevant feeder calf price differentials and showed the marginal prices for characteristics can fluctuate considerably in only a few years. The relative value of feeder cattle price determinants can remain relatively unchanged over a period of years, but the magnitude of price differentials is more likely to change.

A closer look at Sartwelle et al. (1996a) and Smith et al. (2000) provides a snapshot of the changing breed preferences of cattle buyers throughout the 1980s and 1990s. The relative importance of frame size, muscling and horns remained similar to previous research. However, the price differences attributed to breed influence provide a long-run perspective on how changing buyer preferences transformed the genetic makeup of today's cowherd.

Research from the 1960s and 1970s showed English and English-cross calves were generally among the most preferred feeder calf breeds (Williamson et al. 1961 and James and Farris 1971). Starting in the late 1970s and early 1980s, Exotic- or Continental-influenced calves generated the highest breed premiums at auction market. For instance, Lambert et al. (1989) and Kuehn (1979) found that Charolais-influenced calves brought $0.80 to $1.25 per cwt. more than Herefords. Sartwelle et al. (1996a) showed one of the largest premiums for Continental-cross steers over Herefords at $3.63 per cwt. and an advantage of nearly $0.90 per cwt. compared to Hereford-Angus-cross steers. Angus-influenced and black-hided calves began to command the highest breed premiums starting in the late 1990s and early 2000s. In Smith et al. (2000), Angus cattle were discounted relative to Continental-influenced cattle in 1997 but were not statistically different in 1999. While Herefords received discounts of $8.37 and $4.76 per cwt., respectively, to Angus-influenced calves in 1997 and 1999. Discounts for dairy- and Longhorn-influenced calves were generally the highest in each study receiving discounts of between $10 and $25 per cwt.

The results of Smith et al. (2000) were confirmed in later research by Schulz et al. (2010). Data were collected on approximately 8,200 sale lots in Dodge City, Kansas, and Carthage, Missouri, feeder cattle auctions. The hedonic pricing model was similar to Sartwelle et al. (1996a) and Schroeder et al. (1988); however, the research also included a separate variable for hide color. Angus-influenced calves received the highest premiums at $5.59 per cwt. more than Hereford calves, while Angus-Hereford-cross and Continental-cross calves received premiums of $5.22 and $1.78 per cwt., respectively. Similarly, Longhorn and dairy-influenced calves received discounts of more than $10 per cwt., and large-framed and heavy-muscled calves each received premiums. Over the course of two decades, research showed that Hereford calves no longer held a dominant position as the preferred breed of feeder calf buyers. Instead, Angus, Angus-cross and Continental-cross calves are commanding the highest premiums in current feeder calf markets (Schultz et al. 2010).

Research in the 1980s and 1990s focused on the benefits of preconditioned calves. Preconditioning refers to the management practices implemented around weaning that ease a calf's transition to stocker or feedlot environments. The elements of a preconditioning program can vary based on management but generally include weaning, vaccinations, deworming and a transition to bunk feeding and automatic watering systems for a set time period. The program embodies the value-added management approach to raising calves. Theoretically, the increased cost of preconditioning can be returned to cow-calf producers through auction market premiums from stocker and feedlot buyers who recognize the performance and carcass quality advantages of healthier calves.

One of the most prominent Extension-based preconditioning programs became the Texas A&M Ranch to Rail program developed in 1992. With more than 1,700 ranches from 10 states participating in the program, it quickly became one of the most referenced sources on the costs and benefits of preconditioning calves and retaining ownership of those calves through the feedlot phase. In the program's first 10 years, the average net return on Ranch to Rail calves had been $74.54 per head, and average returns were profitable in seven of those years. The challenge was the $500 per head range in returns between high and low return ranches. Most of these differences can be attributed to death-loss and health-related costs. In 2001, average medicine costs were $10.06 per head with a range from $0 to $59.20. Healthy calves raised in the program had an average daily gain of 2.85 lbs. and a $56.20 per cwt. total cost of gain. The calves graded 56 percent USDA Choice and had an average net return of $174.61 per head (McNeill 2001).

The detailed financial and performance data available through the Texas A&M Ranch to Rail program made it an ideal source for the economic analysis of value-added management from the pasture to finishing stages. However, the Ranch to Rail program data only looked at the benefits of preconditioning based on retained ownership through the feedlot. With the majority of cow-calf producers selling calves at weaning, economists needed to determine if the additional cost of preconditioning were rewarded through higher feeder calf market prices. Lalman and Smith (2001) summarized existing preconditioning literature in the Extension bulletin "Effects of Preconditioning on Health, Performance and Prices of Weaned Calves." The researchers compared 1982 to 1987 average sale prices of preconditioned cattle sold through a Lincoln County, Oklahoma, auction market with the average weighted prices for cattle sold at the Oklahoma National Stockyards in Oklahoma City during the same week. The preconditioned cattle had to meet minimum requirements to participate in the sale. Each lot needed at least 10 head of the same sex. Thirty days prior to the sale, calves needed to be weaned, castrated, dewormed, treated for external parasites, and vaccinated against infectious bovine rhinotracheitis (IBR), bovine viral diarrhea virus (BVD), parainfluenza type 3 (PI3), 5-way leptospirosis (lepto) and 4-way clostridial vaccines. Also, the cattle received at least of 200 lbs. of commercial preconditioning feed within 21 days of the sale.

In 1982, preconditioned steers received a $4.24 per cwt. premium while heifers received $2.76 per cwt. The sale premium for preconditioned calves compared to similar Oklahoma City calves grew to more than $8.50 per cwt. for each sex by 1987. To complement these data, Lalman and Smith (2001) provided Colorado State University research highlighting price differences of weaned and vaccinated calves sold through SLA from 1994 to 2000. The data showed preconditioned calf premiums as high as $3.66 per cwt. over non-weaned, non-vaccinated calves. These summaries provided insight on the value of preconditioning to feeder calf buyers, but a more thorough economic analysis was still needed.

The first hedonic pricing study on preconditioned calves was published by Avent et al. in 2004. The researchers understood the challenge preconditioning presented cow-calf producers. Growing interest in beef quality assurance programs and strategic alliances made the value-added benefits of preconditioning a popular industry topic. However, auction market premiums needed to sufficiently cover the costs for preconditioning in order for it to be widely accepted by cow-calf producers. The research included a survey of Texas Cattle Feeders Association feedlot managers, estimated budgets for preconditioning and a hedonic pricing model based on preconditioned calf sales at Joplin Regional Stockyards, Joplin, Missouri, in 2000. The feedlot survey identified the perceived benefits of preconditioning programs. Managers estimated that morbidity rates decreased from 36.4 percent to 9.2 percent and death loss changed from 4.3 percent to 1.5 percent when calves were preconditioned. These health improvements led to better feedlot performance and carcass quality. Estimated average daily gain improved 0.3 lbs. per day and feed efficiency increased 0.6 lbs. Furthermore, the percentage of USDA Choice grading cattle increased and out cattle decreased in preconditioned calves.

Sponsored preconditioned calf sales were gaining popularity, but producers generally had mixed feelings on the success of these programs. Cow-calf producers often felt misled by organizers when the prices received for their preconditioned calves were often less than expected premiums (Avent et al. 2004). Surveyed TCFA feedlot managers estimated preconditioned calves were worth $5.25 per cwt. more on average than non-preconditioned calves. However, auction market premiums for preconditioned calves were generally less than survey results. Using a hedonic pricing model similar to past research, Avent et al. (2004) estimated the price differentials on 1,249 lots of cattle weighing 300 to 699 lbs. The Joplin preconditioned calf sales offered two preconditioning options for sale participants, and these options were treated as dummy variables in the analysis.

The estimates in the pricing model were similar to past research. Lot size and weight had a statistically significant non-linear relationship to price, while light-muscled, small-framed, and unhealthy cattle received discounts. Angus cattle received the largest breed premiums and steers brought more than heifers. Preconditioned calves received premiums of $3.30 and $1.94 per cwt., and higher premium were given to calves from more rigorous health programs. The researchers estimated the revenue and costs of preconditioning through a partial budget comparison. The budget compared the cost and returns based on varying performance, treatment costs and morbidity. Based on the best case scenarios of high gain, low morbidity and low medical costs, the researchers determined the auction market premiums for preconditioning were not sufficient to cover marginal costs.

Dhuyvetter et al. (2005) added to previous preconditioned calf hedonic pricing and budgeting research. Similar to Advent et al. (2004), the study estimated feeder calf prices based on data from preconditioned calf auctions and developed a comparative budget using the model estimates and existing production literature. An additional element of this research was the review of studies estimating preconditioning program value to feedlots. The study used sale data on preconditioned calves marketed through a Kansas auction market from fall 1999 to winter 2004 to estimate the price effects. The hedonic model was consistent with previous research and accounted for cattle characteristics, such as breed/color, base weight, sex and condition, and market characteristics including lot size and sale order. The study found preconditioning premiums for fall-sold calves were $4.48 to $5.48 per cwt. These premiums were smaller for calves sold in the winter and heavyweight calves. Preconditioning premiums were also smaller during strong cattle markets.

The researchers built a projected budget based on a 45-day preconditioned calf program. The budget looked at the influence of average daily gain, death loss, costs and feeder calf prices on preconditioning program returns. The budget used the $4.48 per cwt. estimated preconditioning premium to determine auction revenue and found preconditioning was profitable in each budget scenario. The net return on preconditioning ranged from $2.10 to $20.78 per head across all scenarios with an expected return of around $14 per head. Past research showed a $40 to $60 per head advantage for preconditioned calves in the feedlot. Dhuyvetter et al. (2005) determined this value would command a $7 to $11 per cwt. premium for preconditioned calves at auction.

The difference between potential premiums and hedonic model estimates can be attributed to the health risk that exists even with preconditioned calves. Net returns for healthy and sick cattle in the Texas A&M Ranch to Rail program illustrate this point. The average difference between the healthy and sick calves from 1992 to 2001 was $91.77 per head. The annual range was $49.55 to $151.18 per head. The difference represents the auction discount that would apply to each preconditioned calf that becomes sick. Since preconditioning cannot guarantee that cattle will not become sick, the Dhuyvetter et al. (2005) used the Texas A&M Ranch to Rail data to develop a linear relationship between the percentage of sick calves and per head net returns. The result was a linear trend showing a 10 percent increase in calf sickness decreased feedlot net returns $9.20 per head.

The value difference between traditional preconditioning programs and third-party certified preconditioning programs was the focus of Bulut and Lawrence in 2006. Their study evaluated 19,172 lots of cattle sold at Iowa sale barns in 2005 and 2006. Thirty-seven percent of the calves were preconditioned using a certified vaccination program and weaned at least 30 days. Seventeen percent were preconditioned without the use of a certified health program. Partial preconditioning claims – weaned at least 30 days or vaccinated – were made by 37 percent of sale lots, and nine percent of calves had no form of preconditioning. The economists noted that third-party certification of preconditioning can have value in making seller claims more credible through the verification of a local veterinarian or private company. The success of these certification programs in delivering extra value to sellers depends on the integrity of the program and its procedures. However, a successful low-cost third-party certification can improve information exchange and partially separate high and low quality cattle at auction markets (Bulut and Lawrence 2006). The research used a pricing model that accounted for most of the cattle and market characteristics of past hedonic analyses. The researchers used a dummy variable for age to estimate separate price effects for calves and yearlings. Researchers noted that yearlings are typically considered preconditioned animals at auction markets since they are more mature and health is generally not an issue. Calf vaccination and weaning categories were defined with five dummy variables where the base was an unvaccinated, non-weaned lot of calves: 1) certified vaccination and weaned at least 30 days, 2) uncertified vaccination and weaned at least 30 days, 3) vaccinated and weaned for other or unknown length, 4) vaccinated but not weaned, and 5) weaned but not vaccinated.

Parameter estimates were consistent with previous studies, and the premiums for certified vaccination and weaning programs were larger than other preconditioning programs. Compared to unvaccinated and non-weaned calves, calves given certified vaccinations and weaned at least 30 days received a $6.15 per cwt premium. The premiums were around $3 per cwt. for calves given uncertified vaccinations and weaned at least 30 days and calves vaccinated and weaned for other or unknown length. An F-test showed these two programs received marketplace incentives that were not statistically different from each other. Calves vaccinated but not weaned received a $2.42 per cwt. premium, and weaned but not vaccinated calves earned a premium of $1.70 per cwt. (Bulut and Lawrence 2006).

The preconditioning premiums are higher than those found in previous research, but the value of other parameter estimates were similar to past studies. The researchers found the average participation cost for third-party certification was around $1 per head. With a $3 per cwt. advantage over non-certified preconditioning programs, Bulut and Lawrence (2006) said producers could justify participating in third-party certified preconditioning programs. They also noted the value of uncertified precondition programs was the same as the value of vaccinated calves with less than 30-days or unknown weaning periods, implying that the market pools the value of these claims even with the greater investment of the later claim.

Lawrence and Yeboah provided one of the first studies on the value of source verification in Iowa feeder calf auctions in 2002. Source verification was relatively new to the beef industry at this time. The researchers defined it as the identification of the origin and ownership of cattle and the management practices utilized by the cow-calf producer. Auction markets, cattlemen's organizations and Extension services typically organized source verification programs. Participating producers would agree to specific management guidelines involving the health, nutrition, handling and marketing of their cattle. Program cattle would be identified through a special ear tag. The source verification program provided buyers with more detailed management information on each lot and the convenience of assembled lots of larger, more uniform groups of cattle. The Iowa-Missouri Beef Improvement Organization source verification sales from 1997 to 2000 were evaluated by Lawrence and Yeboah.

The program provided cow-calf producers with clearly defined standards for cattle management and marketing and included specifics on participating veterinarians for administering vaccinations and who could tag program cattle. Each tag included detailed information that could be traced back to the participating farm and the phone number of the participating auction market to facilitate trace back. The program cost participating producers $1 per head, and the information was maintained by a central auction market. Program cattle were sold on special sale dates that were promoted to prospective buyers and sellers in advance. On sale day, cattle were weighed and sorted by sex, frame size, muscle score, weight, and breed or color. They were then grouped into truckload or half-truckload lot sizes according to these characteristics. A lot could potentially include cattle from as many as 15 to 20 different ranches, but each animal was individually identified (Lawrence and Yeboah 2002).

The model developed by Lawrence and Yeboah (2002) was similar to previous studies. However, the model did not include a number of variables that were relevant in past research, such as breed, weight variation within the lot, frame size, fill and flesh, which could make the coefficient estimates biased. The research estimated regression models using three different datasets: 1) combined regular and special sale data, 2) special sale heifers and steers weighing less than 600 lbs., and 3) special sale heifers and steers weighing more than 600 lbs. The resulting value of source verification in the models came back mixed. The value of source verification was positive for the combined and heavier calf dataset, but the estimate was not statistically different than zero. For lightweight calves, the $1.30 per cwt. premium for source verification was statistically significant.

The economists noted one weakness in their research. The influence of source verification and the effect of larger, more uniform lot size on special sale prices were impossible to separate based on the available data. These traits were a bundled benefit for buyers participating in the source-verified sales. The economists estimated the combined benefit of selling larger, more uniformed lots of source-verified cattle using the average lot sizes for both the source-verified and regular calf sales. The resulting premium was $2.50 and $5.07 per cwt. for heavyweight and lightweight calves, respectively, compared to smaller lot sizes of non-program cattle at regular auction. Lawrence and Yeboah (2002) argued the greatest benefit of the special sales came through the sorted and pooled lots. Typically, buyers are burdened with grouping cattle into similar sized lots with little or no information on the cattle. They noted that established health and genetic standards could influence price, but the bundled effect could not be separated from the value of source verification. Despite these challenges, the results show a premium for calves sold through source-verified sales. The research also showed a positive relationship between value-added management and improved information flow on feeder calf prices.

2.2.2 Empirical Hedonic Pricing Studies Involving Information Exchange in Feeder Cattle and Calf Markets

In the 1940s to 1970s, feeder calf price hedonic research depended on regional and local data from traditional auction markets. Sullivan and Linton (1981) provided additional support for this methodology by applying the same modeling procedures to transaction level data at Alabama feeder calf market board sales. The study compared the sale results of these special market board sales to traditional auction markets. Auction markets throughout Alabama were traditionally thin, making it difficult for order buyers to assemble uniform truckloads of cattle to ship to Midwest and Central Plains feedlots. This challenge led to producers organizing market board sales to create greater coordination between cow-calf producers and feedlot owners.

Buyers and sellers benefitted from the marketing efficiencies of market board sales. Producers sold calves direct from the ranch, which lowered sale commissions and eliminated shrinkage and transportation costs. Marketing costs of auction markets were three and a half times the cost of board sales. The convenience of board sales made them appealing to feedlot order buyers. The average lot size of board sales was more than 50 head, while auction markets regularly sold in lots of less than five head and burdened buyers with the risk and cost of assembling a truckload for feedlot delivery. An additional component of these sales was the producer-supplied description of each lot sold through the market board sale. Sullivan and Linton (1981) used this information to develop a price-dependant regression model for these sales.

The characteristics measured in this study provided notable differences to past hedonic pricing models. A critical component of Sullivan and Linton's (1981) analysis were the on-farm visits for producers participating in the market board sales. By visiting 162 farms, the researchers measured calf muscling, frame size, age, finish, presence of defects, weight variability within the lot, access to cattle and show site. These results were then compared to an auction market regression including calf muscling, frame size, presence of defects, weight, breed, grade, sex and lot size. The initial regression of market board sale results evaluated lot size, breed, straightbred or crossbred, sex, producer-estimated sale weight, USDA grade, time of sale and difference between sale and delivery date. The results showed that buyers paid a premium for larger lots of lightweight, medium-framed, straightbred steers with British influence. Producers received a discount of $0.18 per cwt. for each additional week between the sale and delivery date, and calves selling in late May board sales received a premium over cattle sold in April and the first half of May.

Sullivan and Linton (1981) determined there were distinct marketing advantages for sellers in market board sales. The feeder cattle sold were direct off the farm, which reduced stress and exposure to health threats. That resulted in a $5.81 per cwt. premium, after all costs, over similar calves selling in Alabama auction markets. The information provided to sellers statistically influenced the price received for feeder cattle and improved the information efficiency of market board sales. The study showed how accurate market information can influence the prices received for cattle and addressed the need for greater vertical coordination between producers and buyers.

Turner et al. (1991) researched the price differences in cattle marketed through three Georgia teleauctions from 1977 to 1988. A noted benefit of teleauctions was the higher level of information required, and the researchers predicted that hedonic models from teleauction data would explain more price variation than models from traditional auction markets. The regression model included some variables estimated in previous models and new variables to account for shrink, allowable culls at delivery, shipment to pick-up location, corn futures price (i.e., expected feeding cost), nearby sale barn price (i.e., local market influences), total number of lots sold, total number of lots sold squared and total number of buyers (i.e., competitive pressure).

A separate regression equation was estimated for each auction market, and each model reported similar results. The researchers compared their results to those of Schroder et al. (1988) and Lambert et al. (1989), which used data from Kansas auction markets in the late 1980s. Large discounts for small frame size were statistically significant across each study and ranged from $4.10 to $9.80 per cwt. Breed influence resulted in different premiums and discounts. In each study, Hereford calves served as the base. However, Schroeder et al. and Lambert et al. each found Angus calves to be at a discount of $1.74 to $6.23 per cwt., and Lambert et al. also found a $0.88 to $1.05 per cwt. premium for Continental cattle. Turner et al. found Angus calves brought a $0.65 per cwt. premium and Continental calves received a $3.00 per cwt. discount. Studies prior to Schroder et al. and Lambert et al. each documented market advantages for Hereford-influenced feeder calves. The research by Turner et al. noted a transition in breed preference among buyers for Angus-influenced animals that would become common among studies throughout the remaining two decades. The use of feeder cattle futures to measure the local markets efficiency in transmitting national prices was shared by the teleauction market and Schroeder et al. studies. The coefficient range for Turner et al. (1991) was 0.68 to 1.01, while the Schroeder et al. (1988) regression coefficients ranged from 0.314

to 0.983. The results show that Georgia teleauction buyers are more efficient in reflecting current market conditions into their pricing of feeder calves. Another interesting note was the difference in optimal lot size between teleauctions and the regional auction markets. The optimal lot size for the Turner et al. study was between 143 and 276, while the other two studies had an optimal lot size ranging between 46 and 64 head. Teleauction markets also had an average lot size of between 72 and 151, illustrating that teleauction buyers preferred larger runs of cattle than typical auction market buyers.

A later study from Turner et al. (1993) looked at the influence of information and seller reputation on feeder calf price using the same Georgia teleauction market information. The economists noted that reputation should not influence prices in a perfectly competitive market where complete information exists on cattle and market characteristics. They argue that perfect and complete information flow is rarely achieved in competitive markets, and producer reputation can serve as a form of product differentiation. The purpose of their research was to extend the 1991 research model to include the potential influence of seller reputation on the price of feeder cattle.

Reputation does not influence price when accurate information on calf characteristics is efficiently transferred to buyers through the market. Instead, price is accurately reflected through the characteristics of the sale lot. The researchers also stressed that reputation can be positively or negatively correlated to prices depending on the individual producer's ability, or reputation, to produce calves with an actual quality that meets or exceeds the buyers expected quality. To measure the reputation effect, the study added a reputation dummy variable to the 1991 model to account for when a producer had previously marketed cattle at the auction market. It is important to note that reputation was not measured directly – previous sale experience served as a proxy variable for seller reputation. Ninety-one producers were identified as having a reputation in three respective teleauction markets, and 16 sellers had statistically significant reputations (11 positive and five negative). The Georgia Farm Bureau auction market did not have a statistically significant reputation coefficient for any of its repeat sellers. This auction market also provided buyers with the most information on cattle characteristics. Therefore, the lack of a statistically significant reputation was not unexpected. Likewise, the auction with the least information on cattle characteristics had the highest number of statistically significant reputation sellers (Turner et al. 1993).

The challenge of efficient information exchange in feeder cattle auctions was evaluated more closely by Chymis et al. in 2004. The researchers noted that market failure and efficiency problems can occur when cattle are sold in live or public cattle auctions. The motivation behind their research came from the practice of revaccinations in the feedlot and stocker industry, and the question "Why do buyers revaccinate if sellers report that their 'cattle have had all of their shots'?" The research examined the susceptibility of feeder cattle markets to asymmetric information problems. Classical economic theory hinges on the assumption that "actors interact in a frictionless economic system where information is available to everybody instantly at no cost" (Chymis et al. 2004, p. 3). Asymmetric information exists when incomplete information exchange among market participants results in only one party having access to the information.

Chymis et al. (2004) said that revaccination could come from a variety of problems – buyers find it difficult to determine if cattle have been vaccinated at live auctions, buyers are not informed about cattle quality (assuming higher quality is associated with vaccinated cattle), buyers do not trust the vaccination used by sellers, or buyers trust sellers but revaccinate for different reasons (co-mingling at sale time or the need for a different vaccination protocol). Not all problems are related to asymmetric information, but the result of each consequence is the same – buyers pay a lower average price for all feeder cattle to recover the cost of revaccination.

The researchers determined that asymmetric information was at least partially responsible for revaccinations and proposed three solutions to create better market differentiation for vaccinated calves: 1) source-verified or traceability programs, 2) third-party certified preconditioning programs, and 3) video or electronic auctions. The benefit of source verification is the ability to create information flow from the processor to the farm. Depending on the program, it can also verify specific calf management characteristics by documenting common practices such as vaccinations. The researchers cautioned that increased vertical coordination is necessary to take advantage of the information flow benefits. Certification programs offer sellers an opportunity to transfer the trust in their management claims to a third party; however, the success of certification depends on buyers trusting the program or third parties responsible for the verification. The economists said that video and electronic markets are a natural evolution from improved information technology. In addition to reduced transaction costs, buyers receive detailed lot descriptions and photos on sale cattle. Sale representatives provide video markets third-party verification by visiting the ranch, photographing the cattle and confirming management practices at the source of production. The study noted that video auction markets are better suited to the management of larger cow-calf operations that can offer truckload lots of cattle to take advantage of the information efficiencies of this market. It would take more coordination for smaller producers to participate in this market (Chymis et al. 2004).

2.3 Empirical Hedonic Pricing Studies Involving Feeder Cattle and Calves at Video Auction Markets

Cattle video and satellite auction markets began in the mid 1970s. The original video auctions began with auction representatives videotaping cattle at the ranch of origin and working with sellers to develop detailed written descriptions of the cattle for sale. The auction would then take place at a central location where a video and description of each sale lot would be shown to potential buyers. Satellite auction markets were a technological evolution from this format. The television auction format provided potential buyers with the convenience of bidding on video auctions through a satellite feed, often eliminating the need for travel (Bailey and Hunnicutt 2002).

Jim Odle was one of the early developers of U.S. video and satellite auction markets. Odle Auction specialized in hosting centralized video auctions in Denver. In 1986, the company merged with Amarillo Livestock Video Auction to form Superior Livestock Auction. The merger provided Odle with the resources to develop a nationwide auction market built on satellite technology. His philosophy was to use technology to increase information flow without changing the way buyers and sellers were accustomed to completing transactions. Cattle viewing, lot descriptions and auction format are similar to traditional auction markets, and buyers are notified if their bid was accepted immediately following the last bid on an individual sale lot. Sellers are a part of the sale process from start to finish. The seller helps develop the lot description shared prior to and during the sale, and they are given the option to reject a bid and no sale their cattle. More than 300 SLA sale representatives work with sellers to consign the cattle, develop accurate lot descriptions and strictly enforce forward contract specifications (Bailey and Hunnicutt 2002 and Superior Livestock Auction 2010).

Satellite and video technology helped the auction market lower transaction costs, but farmers and ranchers have been generally slow to embrace the new technology. Odle organized public seminars, provided satellite downlinks and trained consignment representatives in public relations to educate participants about the new technology. The efforts helped market participants become more comfortable with the new technology, and SLA became the dominant satellite video auction in the United States within five years. Superior Livestock Auction is the United States' largest video auction service selling more than two million cattle annually since 2001 (Bailey and Hunnicutt 2002 and Superior Livestock Auction 2010).

Video and electronic auction markets were quickly embraced by economists as an ideal source for hedonic pricing analysis. Turner et al. (1991) summarized the five benefits of these markets: 1) improved market information, 2) improved operational market efficiency, 3) improved pricing accuracy, 4) increased competition, and 5) improved market accessibility for buyers and sellers. Electronic auction markets reduce asymmetric information problems and clarify the price differentials based on different lot and market characteristics.

Feeder calf hedonic pricing models using video auction market data first appeared in 1991 when Bailey et al. compared more than 2,000 lots of calves sold through SLA with cattle sold in three regional auction markets. The purpose of the research was to compare the relative prices of each auction market and describe how the video auction markets function. The economists noticed marked differences in the groups of cattle sold through each market. For a simplified comparison, the study looked at SLA and Dodge City, Kansas, auction markets. On average, video auction calves were 20 lbs. heavier than those sold in Dodge City. Bailey et al. said cattle breeds were generally more aggregated for video auction descriptions, but cattle sold on video also had a higher percentage of English-influenced cattle with 82 percent of the lots in this category compared to 63 percent in Dodge City. The researchers noted that this provided the video auction with a slight advantage in quality since English-influenced cross cattle received a premium based on the model estimates. Average lot sizes were larger in video auctions to accommodate for truckload-sized sale lots. The SLA average of 180 head was nearly nine times the size of the average lot size at the regional market. To account for the difference in lot size, Bailey et al. adjusted their results to account for lot size differences and develop more accurate comparisons between the SLA sales data and regional auction market information.

Bailey et al. (1991) developed a simplified version of the feeder calf hedonic model developed by Schroeder et al. (1988) to determine the price differentials in video auction markets. The pricing model accounted for weight, lot size, breed, horns, frame and flesh variables. Lot size was also included as a squared variable, and the nearby futures price was included as a proxy for market conditions. The resulting model showed a statistically significant $4.04 per cwt. premium for large-framed calves. Light-flesh condition consistently received a premium of more than $4 per cwt. compared to calves of light-medium to heavy flesh. Breed influence was not a statistically significant price determinant in the model. Each additional calf sold in a lot increased per hundredweight premiums $0.004, but lot-size squared was not statistically significant.

The study also compared the sale prices received at SLA with regional auctions in Oklahoma City, Oklahoma; Greeley, Colorado; and Dodge City, Kansas. After accounting for direct transaction costs, calf quality and delivery dates, the researchers noted buyers were willing to pay statistically higher prices for cattle at video auctions. The adjusted net price received by SLA sellers was $0.95 to $3.36 per cwt. higher than the comparable regional auction markets. Bailey et al. (1991) said one reason buyers are willing to pay sellers more for cattle purchased at video auction is the lower overall transaction costs associated with video markets. Cattle sold through SLA do not incur shipping or shrink costs, while commissions and fees generally run at a cost similar to regional auction markets. Sellers through video auctions have a pencil shrink adjustment to their prices. However, the adjustment is generally less than the combined cost of shrink and trucking. When combined with the quality adjustment for SLA calves (mainly coming through larger lot sizes), the result is a $1.09 to $1.65 per cwt. premium over the observed regional markets.

Bailey et al. (1991) concluded satellite auction markets provide cattle producers a higher net price than regional auction markets mainly due to reduced costs for shipping and shrink. They also said larger lot sizes in video auction markets eliminate the need for comingling and result in fewer disease threats, less cattle stress and fewer health problems. These advantages are passed on from buyers to sellers in higher prices than traditional markets. The researchers predicted that video auction markets are likely to shrink the market area of regional auctions in the future. The lower transaction costs of video auction markets provide a competitive alternative to sellers who would need to transport cattle long distances to sell at regional markets. Consequently, sellers close to regional markets will have lower trucking costs and receive a higher market price at regional markets than more distant producers.

In 1993, Bailey et al. again looked at data from SLA and the Oklahoma City National Stockyards to evaluate buyer concentration at feeder cattle auctions. Concentration at the fed cattle level had been an ongoing debate in the cow-calf industry, but little was known about buyer concentration at the feeder cattle level. Bailey et al. recognized that a smaller number of order buyers could carry larger influence in regional feeder cattle markets due to trends in consolidation throughout the feeding industry and an increase in the number of large feedlots. To examine the level of concentration in these markets, the economists evaluated buyer pricing behavior through sale prices at individual auctions from 1987 to 1989 in markets that best provided accurate information about feeder cattle buyer concentration. Their prediction was that buyer behavior in individual feeder calf auction markets would reflect the greater concentration reflected in the industry as a whole.

Concentration was defined by the relative dispersion of sales volume among buyers at an individual sale on a particular day. Bailey et al. (1993) reported buyer concentration levels in two forms. The four-firm concentration ratio, also referred to as CR_4, is one of the most commonly used measures of concentration and was the first method applied. The CR_4 measures concentration as a partial index indicating the market share for the four largest firms, and it only requires knowing the total market size and the market shares of the four largest firms to calculate. The second method applied by the economists was a summary index called the Herfindahl Index (HI). It measures the relative concentration of all firms in a market rather than only the top four. It provides a measure of firm size and dispersion in a market. A zero implies atomistic competition and a value of one indicates a monopsony.

The hedonic pricing model developed by Bailey et al. (1993) included more variables in the regression analysis than the previous video auction market study. The economists included lot characteristics for lot size, lot size squared, weight, weight squared, truckload quantity, weight risk, delivery miles, breed, flesh, frame, horns and region of origin. They also accounted for market characteristics including seasonality, futures price, delivery days, HI measure and yearly dummy variables. Weight risk is a calculated ratio of the acceptable level of weight variance a lot of cattle can exhibit above the estimated delivery weight without a discount and the price slide specified by the seller. A price slide is the cents per pound sale price adjustment that is applied when the average delivery weight of a sale lot differs from the estimated base weight in the lot description. The slide can be negative or positive, but in most cases, the slide was used as a discount to calves heavier than their estimated weight.

The research showed that concentration is seasonal in each auction market with the first six months of the year showing larger concentration levels than the last six. Concentration mirrored the seasonality of when cattle are placed on feed indicating that large-volume feedlots and order buyers purchase more cattle during the first half of the year. Placements are typically the lowest during the late summer and early fall, which coincided with lower monthly market concentration from August to October. The video auction market showed slightly less concentration than the regional market. However, fall delivered calves make up the largest sale volume for SLA, while Oklahoma City had its highest volume in the spring months. This trend helped explain the smaller concentration measures. SLA was generally not dominated by feedlot buyers. Bailey et al. (1993) also noted that concentration appeared to be trending slightly upward over time in the video auction market, and trends appeared to be similar with the regional market. They cautioned reading too much into the trend analysis for the regional market as only two years of sale dates were analyzed for concentration.

The regression results in the study were comparable to past hedonic models that analyzed traditional auction markets, and the results are similar to the work of the previous video auction study conducted by Bailey et al. in 1991. A closer examination of the regression coefficient for HI revealed some new discoveries for buyer concentration. Similar to Schroeder et al. (1988), the researchers stratified the data based on sex and a weight break at 600 lbs. Increased concentration had a statistically significant negative effect on prices video auction prices in each model. However, the models based on stratified data showed that steers weighing 600 lbs. or more and heifers weighing less than 600 lbs. experienced statistically significant discounts based on concentration effects. Bailey et al. (1993) noted that the market for lightweight heifers can be extremely thin during the early summer video auctions, and high buyer concentration is often prevalent during these times. The researchers said these two trends result in a concentration effect that likely depresses the lightweight-heifer market prices. Heavyweight steer markets face downward market prices due to the concentration of large-volume feedlots and order buyers that want to purchase these calves. The result of increased concentration in this market decreases heavyweight steer prices as much as $0.80 per cwt. The researchers suggest that this trend shows that buyer market power in video auction markets is greatest for cattle going into feedlots.

Bailey et al. (1991) concluded that concentration is a symptom of large-volume feedlot order buyer presence in the feeder calf market. The study showed increased buyer concentration has depressed feeder calf prices over time in these individual markets and follows a seasonal pattern based on the nation's feedlot placement trends. The research found high levels of concentration in feeder cattle markets, but Bailey et al. noted the concentration level within feeder calf auction markets is relatively low compared to concentration levels in other beef industry sectors such as the meat packing industry. The highest CR_4 at Oklahoma City National Stockyards and SLA were 63.7 and 49.6 percent, respectively, while the packing concentration level was considered to be more than 80 percent for steers and heifers during the same time period.

Superior Livestock Auction data were used to examine buyer concentration in two additional studies in 1995 and 1996 (Bailey et al. 1995 and Fawson et al. 1996). The purpose of the 1995 study was to define major market areas for feeder cattle buyers and develop a spatial statistical test to discover feeder cattle price differences when market locations are dominated by buyers from one market area or located in overlapping market areas. Bailey et al. (1995) said that any test on monopolistic behavior in feeder cattle markets requires a clear delineation of market areas. Their argument was that buyers in spatially separated markets only compete directly in specific procurement areas, and the price they are willing to pay within their defined market area could be different than in locations that service more than one area. Using data from SLA, the researchers determined the size and shape of primary marketing areas based on national buying trends and the cattle shipment patterns to U.S. feeding areas. The boundary areas of each market area were mapped by calculating spatial statistics from the shipping data.

The regression developed for this study was similar to the model developed by Bailey et al. in 1991 and 1993. Data used for the hedonic pricing model included 103 SLA sales from January 1987 to December 1992. The researchers included a number of new variables in this model: uniformity, delivery miles, delivery-miles squared, buyer concentration, market-area overlap and sale order. Feeder calf buyer concentration was defined as the proportion of cattle purchased in a feeding area from one particular location, and mileage between the location of the cattle and their purchase destination was used to estimate price differences based on transportation costs. Market overlap was a dummy variable that equaled one if the lot was located in a state with multiple market areas and zero otherwise (Bailey et al. 1995).

The use of spatial statistics in the study determined that marketing areas for feeder calves are large, irregular in shape and overlap considerably. Bailey et al. (1995) showed four primary feeding areas in the United States: Omaha, Nebraska, Greeley, Colorado, Dodge City, Kansas, and Amarillo, Texas. Comparing the market areas for Dodge City and Amarillo the researchers noted that transportation costs determine a market area's shape, size and purchase pattern distribution. Buyers in Omaha and Amarillo are located near the boundaries of their respective areas. Amarillo buyers focus on purchasing south of their location and Omaha buyers purchase a relatively large proportion of cattle to the north of the city. Buyers in Greeley and Dodge City purchase cattle from every direction in their respective areas and compete with buyers in the other feeding areas more frequently for cattle. Regression results showed that buyers tend to absorb the freight costs on cattle that are delivered more than 200 miles. Less than 20 percent of lots are shipped fewer than 200 miles, while more than 70 percent of cattle are shipped less than 600 miles. The parameter estimate for buyer concentration was -1.127 indicating that a county's feeder cattle prices are lower when buyers from one feeding area dominate its purchases. A buyer concentration variable equal to one would indicate a monopsony, and the resulting discount for a 500 pound steer would be approximately $5 per head based on this regression estimate. There was a $1.127 per cwt. premium for sellers when two or more market areas overlapped, revealing that a competitive market existed in counties located in more than one market area. The results of the other coefficients were consistent with previous work done by Bailey et al. in 1991 and 1993 as well as the hedonic pricing analyses developed from traditional market data.

The results show that regional concentration appears to influence local prices more than what had been reported in previous literature. However, they noted that feeder cattle producers selling through video markets can be confident that market areas are large, and that buyers are willing to absorb part of the transportation costs for cattle shipped long distances (Bailey et al. 1995).

The effect of timing and characteristic-based measures of buyer concentration on feeder cattle auctions were evaluated by Fawson et al. in 1996. The study utilized data from 16,008 lots of cattle sold through SLA from 1990 to 1992. The primary regression model was nearly identical to the previous model developed by Bailey et al. in 1993. The model included a variable for uniformity, and the market structure variable for HI was substituted with CR_4. Fawson et al. estimated various models to look at the influence of CR_4 on sales prices with sex, weight and sale time interaction terms. Dummy variables were constructed to facilitate the interactions. Sex was based on steers and heifers. Weight categories were split into calves weighing less than 600 lbs. and those weighing 600 lbs. and more. Sale time was based on the auction quarter in which each lot was sold. The four largest buyers at each SLA sale were identified by the total number of cattle purchased, and the proportion of cattle purchased in each category by the four firms was calculated for the regression.

The average concentrations in each category showed that heavyweight steer sales had the highest buyer concentration with 48 percent of the sales, on average, being purchased by the four largest-volume buyers. Heavyweight steers and heifers also appeared to have a higher level of buyer concentration than lightweight calves, regardless of which sale quarter they are sold. The first quarter of video auction sales appeared to have the highest amount of buyer concentration, declining steadily as the sale progressed. The regression coefficients for the model based on concentration's interaction with weight and sex categories showed that buyer concentration statistically affected the price of lightweight heifers. When all lightweight heifers in a sale are purchased by the four largest firms, prices for those calves decrease $3.29 per cwt. These results had even greater understanding when evaluated in a model accounting for sex, weight and sale time interactions with concentration. Fawson et al. (1996) said there are statistically significant opportunities for large-volume buyers to strategically time the purchases of lightweight heifers to the second and third quarter of sales. Regression coefficients showed that heavyweight steers and heifer prices are affected most by concentration in the first, third and fourth quarters. Prices for lightweight steers are reduced by concentration in the second quarter of sales, but sellers benefit from concentration in the third and fourth quarters.

Large-volume buyers dominated the purchases in the first part of sales with concentration declining throughout the remainder of the sale. Fawson et al. (1996) offered two explanations for this trend. Large-volume buyers might perceive that it will be more difficult to fill orders as the auction continues, and their best opportunity to purchase the cattle they desire is at the beginning of the sale. The second possibility is that large-volume buyers have better market information at the beginning of sales compared to small buyers. Small buyers may rely on the auction itself as the price information source and may be more passive market participants at the beginning of sales. The results show that buyer behavior can vary greatly between large- and small-volume feeder cattle buyers at video auctions.

Coatney et al. evaluated the feeder calf price determinants in video auction markets using a hedonic pricing model based on a system of equations in 1996. The model was estimated using data from 3,231 lots of cattle sold through SLA in 1992. The model developed for this study was different than previously discussed hedonic pricing models using feeder cattle auction data. The variables utilized in the price-dependent model were grouped based on physical characteristics, seller-added characteristics, climate/environmental influences, market factors, seller characteristics, marketing techniques and selectivity bias.

The research introduced a number of new variables into the hedonic regression not seen in previous studies. The introduction of feed type, drylotting, implants, vaccinations, worming, brucellosis (bangs) vaccination and proportion of put-together cattle variables allowed the economists to account for the value added to sale lots based on management practices. Variables for mixed-lot heifer price slide, proportion of heifers, within-state sales and within-region sales measure the value of marketing characteristics not evaluated in previous studies. The model also included a variable to eliminate selectivity bias in the results due to the exclusion of no-sale lots (Coatney et al. 1996).

The distinguishing element of this study was the use of a system of equations to account for variables within the hedonic pricing models. The values for pencil shrink, average weight, average frame and average flesh were dependent on independent variables used within the model. Coatney et al. (1996) argued the empirical model accounts for the direct effect of feeder cattle characteristics and the indirect effects that come from the direct influence of other endogenous variables in the equation. Biological interactions are a system of individual, but dependent characteristics. The researchers said that a systems approach to the hedonic modeling allows for these biological interactions to be more accurately expressed in feeder cattle price determinants.

The researchers compared the coefficient estimates from the system of equations approach with results estimated through ordinary least squares. Overall, the results of each model were similar. The indirect effects of pencil shrink, frame score and weight had a statistically significant negative effect on feeder cattle prices in the system of equations. The discount associated with frame score stands in contrast to both the OLS results and previous research. Coatney et al. (1996) said the negative influence of frame in the indirect model could reflect a discount for frame size in older feeder cattle, which were more frequent in the dataset compared to younger calves. Cost of gain generally increases for older cattle as frame size increases due to the longer feeding period necessary to reach a finished weight. Many of the seller-added input characteristics such as implants, worming and vaccinations did not contribute statistically to the price of feeder cattle in either model. In addition, marketing technique characteristics including pencil shrink and weight slides were not statistically significant in either model. The economists noted that beef industry profits were relatively high in 1992, and the analysis may reflect those market fundamentals in the magnitude and significance of parameter estimates. They suggested that the price determinants that are statistically significant in profitable years might be the most critical factors for sellers to account for when making management and marketing decisions.

There were four studies that estimated the market incentives for value-added management practices using hedonic pricing models derived from video auction market data. King et al. (2006) looked at the influence of certified health programs on the price of feeder calves using data on 26,502 lots of cattle sold through SLA from 1995 to 2005. The study was groundbreaking for its comprehensive look at the value for certified health programs in feeder calf auctions. The research focused on the price influence of four vaccination programs that are verified by SLA personnel and identified in sale catalogs with a special stamp designating each program. Calves not meeting the requirements for one of these four programs were included as two additional groups: viral vaccinated and not viral vaccinated. Viral vaccinated calves received at least one vaccination for respiratory tract viruses at some point prior to shipment. Not viral vaccinated calves consisted of calves that had not received respiratory tract virus vaccinations prior to shipment.

The four Value-Added Calf (VAC) certified health programs evaluated in the study were VAC 24, VAC 34, VAC 45 and VAC Precon. Calves in the VAC 24 program were two to four months of age and not weaned when they received vaccinations against seven types of clostridia, IBR, PI-3, BVD, bovine respiratory syncytial virus (BRSV), and *Mannheimia haemolytica* or *Pasteurella multocidia* or both. VAC 34 calves were similarly vaccinated prior to weaning against seven types of clostridia, but the vaccination had to occur at branding or two to four weeks prior to shipment. The calves in this program also needed to be vaccinated against IBR, PI-3, BVDV, BRSV, and *Mannheimia haemolytica* or *Pasteurella multocidia* or both two to four weeks prior to shipment. Weaning for 45 days prior to shipment was the major distinguishing point for calves in the VAC 45 program. These calves also had to participate in one of two vaccination protocols. The first option required calves to be vaccinated against seven types of clostridia prior to weaning. This vaccination could occur either at branding or two to four weeks prior to weaning. The calves also needed to be vaccinated against IBR, PI-3, BVDV, BRSV, and *Mannheimia haemolytica* or *Pasteurella multocidia* or both two to four weeks prior to weaning and provided a booster for these vaccinations at weaning. The second option differed in allowing the vaccination against the seven types of clostridia to occur at branding or weaning, and the vaccinations against IBR, PI-3, BVDV, BRSV, and *Mannheimia haemolytica* or *Pasteurella multocidia* or both could occur at weaning with a booster followed according to label instructions. The two program options were not treated differently in sale catalogs, and are generally considered the same in the industry. Therefore, no difference was noted between the two options in the study. The VAC Precon program was developed for calves pulled together from multiple sources. It required that calves be weaned at least 60 days prior to shipment and receive vaccinations against IBR, PI-3, BVDV, BRSV and *Mannheimia haemolytica* or *Pasteurella multocidia* or both at the time of arrival and receive the booster vaccinations for these antigens according to label instructions. It should be noted that weaned calves not certified for the VAC 45 or VAC Precon programs were not included in the analysis to isolate the value of weaning to these two programs (King et al. 2006).

The research also looked at the price influence of two marketing programs recently designated in SLA sale catalogs. Natural-market eligible calves were recognized in 2004. To qualify for the program calves are prohibited from receiving antimicrobials or ingredients resulting in antimicrobial residues; feed containing antimicrobial ionophores; feed containing protein derived from mammalian tissue; or synthetic hormones, growth promotants, or anabolic steroids. Furthermore, calves that had received therapeutic treatment must be identified and either removed from the shipment or the seller must approve of their shipment if included. Age-and-source verified cattle were designated in sale catalogs starting in 2005. To participate in this program, producers had to select an ASV program and place the program's radio frequency identification (RFID) tag in the calves left ear prior to delivery. Producers also needed to maintain written birth date records of each calf, or at least record the birth date of the first and last calf born in each sale lot, along with the producers contact information or premise identification number, and enter this information into the national database prior to shipment. Buyers were then allowed to access this information from the database provider (King et al. 2006).

Regression estimates were published for calves that sold from June to September 2005. The researchers did not estimate the value of VAC Precon program calves in this regression due to the small number of observations during that time. The model accounted for a number of variables seen in models developed by Bailey et al. (1991), Schroeder et al. (1988) and other economists including weight, weight squared, lot size, lot size squared, sex, breed, weight variation, frame score, flesh score, presence of horns, implants, home-raised, days between sale and delivery, health program, natural-market eligible, ASV and a dummy variable for each sale date. Coefficient estimates for variables estimated in previous research were generally consistent with past results. Certified health programs consistently received a statistically significant premium compared to calves not weaned or vaccinated. VAC 45 calves received the highest premium at $6.64 per cwt. followed by VAC 34 calves with a $2.45 per cwt. advantage. The market value for VAC 24 calves and non-certified vaccinated calves was statistically the same at $1.17 to $1.43 per cwt. Age-and-source verified calves received a $0.52 per cwt. premium. However, natural-market eligible calves did not receive a statistically significant premium in the SLA sales (King et al. 2006).

King et al. (2006) summarized trends in health program participation and premiums from 1995 to 2005. The percentage of SLA lots certified in the VAC 34 and VAC 45 programs increased steadily over the study. VAC 45 lots increased from 3.2 percent in 1995 and reached a high of 26.8 percent in 2004. Similarly, VAC 34 participation started at 12.7 percent participation and grew to more than 58 percent of sale lots by 2005. While participation in certified health programs increased, the number of calves considered to be non-program vaccinated and not viral vaccinated has decreased. Non-program vaccinated calves were represented in 35 to 47 percent of SLA sales from 1995 to 2000. Since that time, non-vaccinated calves have not made up more than 30 percent of sale lots, reaching a low of 12.6 percent in 2005. The number of non-vaccinated lots in SLA sales has steadily declined from 44.7 to 3.9 percent over the 11-year period.

The research presented by King et al. (2006) revealed that certified health programs can increase the value of feeder calves sold through SLA compared to non-weaned and non-vaccination calves. It also showed that buyer preferences vary based on the type of health program administered to calves. The 2005 premiums for ASV in feeder calf video auction markets reflected the value placed on information transfer between the various segments. The emerging natural market did not translate back to a premium for producers in 2005.

Kellom et al. presented research on the effect of ASV on Montana feeder calf price using SLA data from 2007. The researchers developed a hedonic model using OLS estimation to evaluate the value of ASV, weaning, sex and seasonal difference between June and July sales. The model developed for the research was a simplified version of previous hedonic pricing models. Kellom et al. found the value of age and source vaccination to be $2.13 per cwt. in Montana calves. The value was considerably higher than the $0.52 per cwt. premium found by King et al. Steers received an $8.76 per cwt. premium compared to heifers. Weaning was valued at $2.95 per cwt. A general vaccination program added $2.45 per cwt. to the price of calves. Kellom et al. noted that the average cost for ASV is around $3 per head. Based on the regression results, producers could expect average net returns of $10 per head for age and source verification.

Blank et al. (2006) evaluated 1997 to 2003 Western Video Market sales to determine the price differences in cattle based on region. The researchers used hedonic price modeling to test their hypothesis that California cattle receive lower prices than similar cattle in the Midwest. They believed that Western cattle were at a competitive disadvantage to cattle that were closer to the U.S. feedlot and packing industries in the Central Plains. Additionally, Blank et al. explored the video auction price incentives for value-added management and marketing practices. The analysis was conducted on 1,979 lots of steer calves with an average weight range of 500 to 625 lbs., and only prices from steers with medium flesh score and frame scores of medium or medium-large were evaluated. The regression model estimated the effects of lot size, lot size squared, weight, weight squared, weight variability, region of origin, preconditioning, Quality Assurance Programs, natural-market eligibility, Western Rancher's Beef cooperative participation, implants, bunk breaking, weaning time, forward contract period and breed on the price received for the cattle.

The data used for the study were stratified based on the region of origin, and regression equations were estimated for the entire dataset and each region. Western regions were smaller in area to allow for a more detailed analysis of local markets, while regions in the Rocky Mountains and Central Plains were larger and covered multiple states. The regression results showed that statistically significant price differences existed in seven of the eight regions analyzed in the study. Steers in Western states received discounts of more than $5 per cwt. compared to similar steers from the Central Plains feedlot region. Preconditioning and Quality Assurance Programs received video auction market premiums of $0.81 and $0.92 per cwt., respectively. Also, sellers received an additional $1.27 per cwt. for calves that were weaned 30 days, and natural-market eligible calves earned a premium of $1.60 per cwt. Blank et al. (2006) also evaluated the value-added management and marketing practices by year and found that premiums for weaning time and natural-market eligible steers were the most consistent statistically significant premiums on an annual basis during the seven-year study. Premiums for weaning were statistically significant each of the last six years of the study, ranging from $0.80 to $2.17 per cwt. Natural steers were first designated in the Western Video Market sales in 1999 and received a statistically significant premium in four out of five years ranging from $1.11 to $2.08 per cwt.

The economists also noticed that the number of lots identified as preconditioned, weaned more than 30 days or natural-market eligible increased considerably since 1997. Preconditioned steers made up less than 10 percent of all sale lots during the first four years of the study but climbed to 60 percent in 2001 and were never lower than 50 percent during the remainder of the study. Steers weaned more than 30 days made up less than five percent of sale lots in 1997 and 1999 and participation in weaning grew to around 30 percent of sale lots from 2000 to 2003. Natural-market eligible steers climbed to 13 percent of sale lots in 2003 after not even being designated in lot descriptions in 1997 and 1998, and implanted cattle decreased from 40 to 50 percent in the study's first three years to less than 30 percent in 2003 (Blank et al. 2006).

Blank et al. updated this study with "Video Market Data for Calves and Yearlings Confirms Price Discounts for Western Cattle" in 2009. The new study evaluated data on 4,116 sale lots of calves and 5,147 lots of yearlings from 1997 to 2007. Similar to the previous study, all calves were 500- to 625-pound steers with medium flesh scores and medium or medium-large frame scores. Yearling steers averaged 750 to 925 lbs. Additionally, cattle from split loads, Holstein breed influence and Mexican origin were eliminated from the study. The regression analysis included the same regions used in the 2006 study, but Blank et al. included new variables to account for additional value-added management and marketing practices. The new variables in the calf hedonic pricing model included ASV, Certified Angus Beef® candidates, domestic birth, and weaning for less than 30 days. The yearling model included all of these variables with the exception of the weaning variable and included additional variables for feed type – drylot with hay, drylot with hay and pasture, and pasture-only grazing.

The regression results for calves were similar in relative importance to the 2006 results. The regional differences increased considerably in the updated study with calves from the Rocky

Mountain and West regions receiving discounts from \$8.77 to \$11.63 per cwt. compared to the Central Plains feedlot region. Age-and-source verified steers received a premium of \$5.31 per cwt., while the market value for preconditioned and natural-market eligible steers increased to \$1.37 and \$2.25 per cwt., respectively. Certified Angus Beef® candidates and domestic-born steers also received premiums of \$1.38 and \$3.23 per cwt., respectively. Calves that were not weaned received a discount of \$3.29 per cwt. compared to calves that were weaned more than 30 days. Somewhat surprisingly, the results showed that longer weaning periods did not always lead to larger premiums. Calves weaned less than 30 days received a premium of \$1.29 per cwt. compared to longer weaned steers. Also, bunk-broke steers received statistically significant market discounts of \$1.83 per cwt. (Blank et al. 2009).

Yearling steers were not discounted as heavily based on regional differences. Steers from the Rocky Mountain and West regions were discounted \$6.61 to \$8.29 per cwt. compared to Central Plains yearlings. Premiums for value-added management practices such as preconditioning, ASV and Certified Angus Beef® candidacy all decreased relative to steer calves. Natural-market eligible yearling steers received higher market premiums compared to calves with a premium of \$3.78 per cwt., and steers fed hay were discounted \$0.72 per cwt. compared to grazing yearlings. These two price differentials were also the most consistent statistically significant price signals on an annual basis from 1997 to 2007. The yearly market incentives for natural-market eligible yearlings were also more likely to be larger than for calves (Blank et al. 2009).

2.4 Implications of Previous Research

Faminow and Gum (1986) highlighted the benefits of feeder cattle hedonic pricing studies in using "current information from auction markets to assist in the formation of production decisions (such as the weight at which to sell cattle) and marketing decisions (in particular, lot size determination)." The review of previous research in pricing models provides a variety of insights on the use and development of regression models in feeder cattle pricing. The structural forms and characteristics analyzed in feeder calf models have changed as economic understanding, beef industry structure and marketing information has evolved over the last 50 years.

The information presented also offers an historical perspective on pricing trends as they relate to the feeder calf genetic, management, marketing and market conditions. Relevant variables in the analysis of feeder calf pricing have included weight, weight squared, lot size, lot size squared, sex, frame size, flesh condition, uniformity, breed, region of origin and health. Additional variables have been added over time to serve as proxy variables for expected market conditions and input costs. To account for these variables, researchers have often incorporated the futures market contract prices for feeder cattle and corn. Over the last twenty years, cow-calf producers have also implemented value-added management and marketing practices that have statistically influenced the auction price of feeder calves.

Breed influence, vaccination programs, ASV and natural-beef production have all become more relevant to cow-calf producers as vertical coordination has improved in beef production. Existing research has studied the price effect of these management practices. However, there are opportunities to examine the individual components of these management practices in more detail. Value-added management at the cow-calf level provides the beef industry with calves that meet later production and consumption preferences with the best genetic, management and marketing traits. The popularity of branded Angus beef programs has led to an increase in Angus and black-hided cattle. Previous hedonic pricing research has not addressed whether buyers pay a statistically different price for Angus and other black-hided calves in video auction market sales. Preconditioning programs come in a variety of forms and often combine vaccination and weaning management practices. A number of hedonic pricing studies have looked at the effect of preconditioning on calf prices, but only King et al. (2006) looked at the price effects of different certified health programs. Additional research can confirm the results of King et al., and separate the effects of weaning and respiratory vaccinations on calf prices. Finally, emerging export and domestic marketing programs have created new opportunities for cow-calf producers to document management and market their calves as candidates for natural, NHTC and export markets. Studies by Blank et al. (2006 and 2009) and King et al. have captured some of the price effects of natural market eligibility, but the industry has yet to see a multi-year study that can document the effect of both emerging markets on calf prices.

A trend toward vertical coordination has created a renewed interest in the premiums available for value-added production in the cow-calf sector. This study will provide the industry with new information pertaining to the revenue opportunities that exist for cow-calf producers through vertical coordination in the beef industry. Hedonic pricing models can be used to determine the best revenue-generating opportunities for cow-calf producers. The variables included in the past research should form the foundation for any multiple regression analysis in this area. Video and satellite auction markets are recognized as a national pricing mechanism for feeder cattle in the United States. These markets represent the management and marketing practices of a national cow-calf industry as well as the tastes and preferences of a national stocker and feedlot industry. The review of literature in the area of feeder calf hedonic modeling continues to have a powerful application in the collective understanding of the marginal value assigned to the management of our nation's cow-calf herd. Few data sources in the beef industry can provide an in-depth understanding of price determinants in feeder cattle markets like video auction markets. The previous research in feeder cattle pricing models can be applied to the current genetic, management, marketing and market structure information from video auction markets to discover new information about the relevance of value-added calf production to later beef sectors.

CHAPTER 3 - Theoretical Model

The cow-calf sector serves as the foundation for supplying consumers with a healthy and wholesome beef product. The genetic, management and marketing practices implemented by cow-calf producers have an indirect influence on the value of beef throughout the supply chain. Vertically coordinated production and marketing techniques have become more important as the beef industry focuses on improving the product characteristics desired by U.S. beef consumers. The price of feeder calves is determined by supply from cow-calf producers and demand created by sectors farther down the beef supply chain. Examining the form and function of the U.S. beef supply chain and the theoretical framework of derived-product demand will lead to a better understanding of these complexities and how they influence the value of feeder calves.

3.1 U.S. Beef Supply Chain

The foundation for beef production in the United States begins at the farm or ranch. The financial success of a cow-calf producer depends on each cow in the herd raising a healthy calf from birth until weaning. Cow-calf producers can manage production on the ranch from conception to weaning to improve the performance, quality and profitability of that calf at the ranch and later sectors. Each calf is raised by the cow at the ranch, and within about six months is weaned from its mother and transitioned to the next stage in the beef supply chain.

The majority of U.S. steers and heifers leave the ranch and transition to the stocker or backgrounding sector. These sectors serve as a link pulling together similar calves and managing them with the proper health and nutrition programs to make a successful transition to the feedlot sector. Stocker operators specialize in grazing feeder calves on pasture over a period of months and typically sell the calves to the feedlot sector as yearlings weighing 700 to 850 lbs. Backgrounding operations grow calves in a feedlot atmosphere and slowly transition the nutritional needs of calves from a grass-based to grain-based diet. Another marketing option for weaned calves is to transition from the ranch directly to the feedlot. Feedlots will purchase ranch-direct calves and function more similarly to a backgrounder or stocker operator for an adjustment period and quickly shift these calves to a feedlot diet and finish them to an appropriate slaughter weight.

Regardless of the intermediate path, most calves produced in the United States end up at a feedlot where they are fed to a finished slaughter weight. These fed cattle are then sold to meat packing companies where beef is produced for direct consumption and further processing and ultimately reaches the consumer. The production function that leads to the consumption of beef can be summarized by three equations:

$$Q_{Feeder\ Cattle} = f(Q_{Calves}, Q_{Other\ Inputs}) \quad \textbf{(1)}$$

$$Q_{Fed\ Cattle} = f(Q_{Feeder\ Cattle}, Q_{Calves}, Q_{Other\ Inputs}) \quad \textbf{(2)}$$

$$Q_{Beef} = f\left(Q_{Fed\ Cattle}, Q_{Other\ Inputs}\right). \quad \textbf{(3)}$$

Equation 1 says that the quantity of feeder cattle produced by the stocker and backgrounding sector is function of the number of calves produced by the cow-calf sector and all other inputs for production. Other inputs in each of the three production functions can include, but is certainly not limited to, land, labor, feed and medicine. Equation 2 notes that fed cattle production is dependent on the number of feeder cattle from stocker and backgrounding operators and calves raised by cow-calf producers as well as all other inputs. These fed cattle are then utilized with other inputs in the packing industry to produce beef in Equation 3.

The critical focus for this research is the influence of calf characteristics on the production of feeder and fed cattle in the later beef segments. The production of feeder and fed cattle is dependent on calf characteristics that affect the performance and quality of the end product received by the next sector of the beef industry. Fortunately, the measurements for calf performance and quality are similar for the stocker, backgrounding and feedlot sectors and these characteristics can be viewed inclusively in the quality of feeder cattle.

3.2 Derived Demand for Feeder Calves

The theoretical argument for the derived demand of feeder calves comes from the foundation established by Ladd and Martin in "Prices and Demands for Input Characteristics" (1976). Their research established the derived demand for corn based on the commodity's production and profit functions. The same general understanding can apply to a wide variety of agricultural commodities, including feeder cattle.

The basic production function for feeder cattle produced at the cow-calf level in Equation 1 can be rewritten in the functional form below where Y is $Q_{Feeder\ Cattle}$, X_1 is Q_{Calves} and X_2 is $Q_{Other\ Inputs}$:

$$Y = f(X_1, X_2). \quad \textbf{(4)}$$

The profit function for feeder cattle producers can be derived from the production function in Equation 4 where π is profits, p is the price of feeder cattle, and r_1 and r_2 represent the prices of calves and all other inputs in feeder cattle production, respectively,

$$\pi = pf(X_1, X_2) - r_1X_1 - r_2X_2. \quad \textbf{(5)}$$

The first derivatives of Equation 5 with respect to the inputs X_1 and X_2 are the first order conditions and they represent marginal value to production for each input:

$$\frac{d\pi}{dX_1} = p\frac{dY}{dX_1} - r_1 \quad \textbf{(6)}$$

$$\frac{d\pi}{dX_2} = p\frac{dY}{dX_2} - r_2. \quad \textbf{(7)}$$

Each first order condition can be expressed in a reduced-form equality where MVP_i is the marginal value of production from the i^{th} input and MVC_i is the marginal factor cost of the i^{th} input:

$$MVP_1 = MVC_1 \quad \textbf{(8)}$$

$$MVP_2 = MVC_2. \quad \textbf{(9)}$$

MVP_i represents the change in marginal revenue associated with a change in the quantity of the input i used in production, and MVC_i is the change in variable factor cost resulting from a change in input i. Factor demand equations for each input can be derived by solving the first order conditions in Equations 6 and 7. The resulting equations show that optimal input use is dependent on the price of the output p and inputs used in production r_1 and r_2:

$$X_1^* = f(p, r_1, r_2) \quad \textbf{(10)}$$

$$X_2^* = f(p, r_1, r_2). \quad \textbf{(11)}$$

Calves used in the production of feeder cattle, and ultimately fed cattle and beef production, provide certain characteristics to production that cannot be provided by other inputs. This argument was central to "A New Approach to Consumer Theory" written by Lancaster in 1966, and will be the focus for developing the derived demand for feeder cattle.

The derived demand curve in Equation 10 can be simplified into the expression below where P is the price of each factor:

$$Q_{Calves} = f(P_{Feeder\ Cattle}, P_{Calves}, P_{Other\ Inputs}). \quad \textbf{(12)}$$

Equation 12 shows that the quantity demanded for calves is a function of the price of feeder cattle, price of calves and the price of all other inputs used in feeder cattle production. Economic theory will support that changes in the price of feeder cattle and all other inputs will result in a shift in the demand curve for calves, while a change in the price of calves will result in a change along the demand curve for calves.

3.3 Theoretical Pricing Model

In 1928, agricultural economists were primarily focused on the influence of seasonal and day-to-day variations of supply and demand in determining price. Waugh challenged agricultural economists to look at price variation based on the quality differences among commodities. The objective of this research is to identify and estimate the price determinants for feeder calves sold in SLA video markets. The quantity-dependent factor demand equation derived for calves in the previous section help better understand how the characteristics of an input can influence the price associated with that input at the market. Ladd and Martin (1976) argued that an input's price equals the sum value of the input characteristics to the producer. Their paper discussed situations where various inputs could provide the same characteristic to the production process. In feeder cattle production, calves contribute input characteristics that cannot be provided by other inputs. In other words, Ladd and Martin described calf prices as a product of the characteristics of individual calves. The research presented in this paper predicts that feeder calf prices are a function of calf characteristics at sale time.

Feeder calf market prices reflect the supply and demand conditions of a particular market at a specific point in time. When supply for a market is given, Faminow and Gum (1986) said that calf prices are determined by the demand for an individual lot of cattle. This study assumes that the supply of feeder cattle at an individual video auction on a particular day is fixed. Therefore, the demand for a lot of feeder calves is influenced by the physical traits of the calves sold. Previous research defined calf prices as a function of the physical characteristics (C) of a sale lot and the fundamental market forces (M) of aggregate supply and demand for feeder calves at the observed time:

$$Price_{it} = \sum_k V_{ikt} C_{ikt} + \sum_h R_{ht} M_{ht}. \quad \textbf{(13)}$$

The equation above summarizes the hedonic pricing model relationship where i is an individual lot of calves, k is a specific trait, h is the market influence and t is the auction date. The value of a specific trait in a sale lot is represented by V, and the effect of individual market forces on price is represented by R (Schroeder et al. 1988). Equation 13 indicates the price per hundredweight for each lot of calves is equal to the sum of the marginal value of production for each lot characteristic and the sum influence of market forces at a particular auction.

3.4 Application to Present Research

The U.S. beef supply chain begins with the cow-calf producer raising a healthy calf. Vertical coordination in the beef industry creates market signals that travel back to the ranch in the form of implicit premiums and discounts paid on calf characteristics. Assuming that supply is static at any particular market, the demand for that calf is based on how its traits influence aggregate beef production efficiencies and quality attributes. That demand can be measured by analyzing the market value assigned to each characteristic. Previous research has developed the theoretical foundation for analyzing these price determinants. These studies also provide insight for the relevant genetic, management, marketing and market structure variables to include in an empirical model involving the price determinants of calves sold at SLA video market sales.

CHAPTER 4 - Materials and Methods

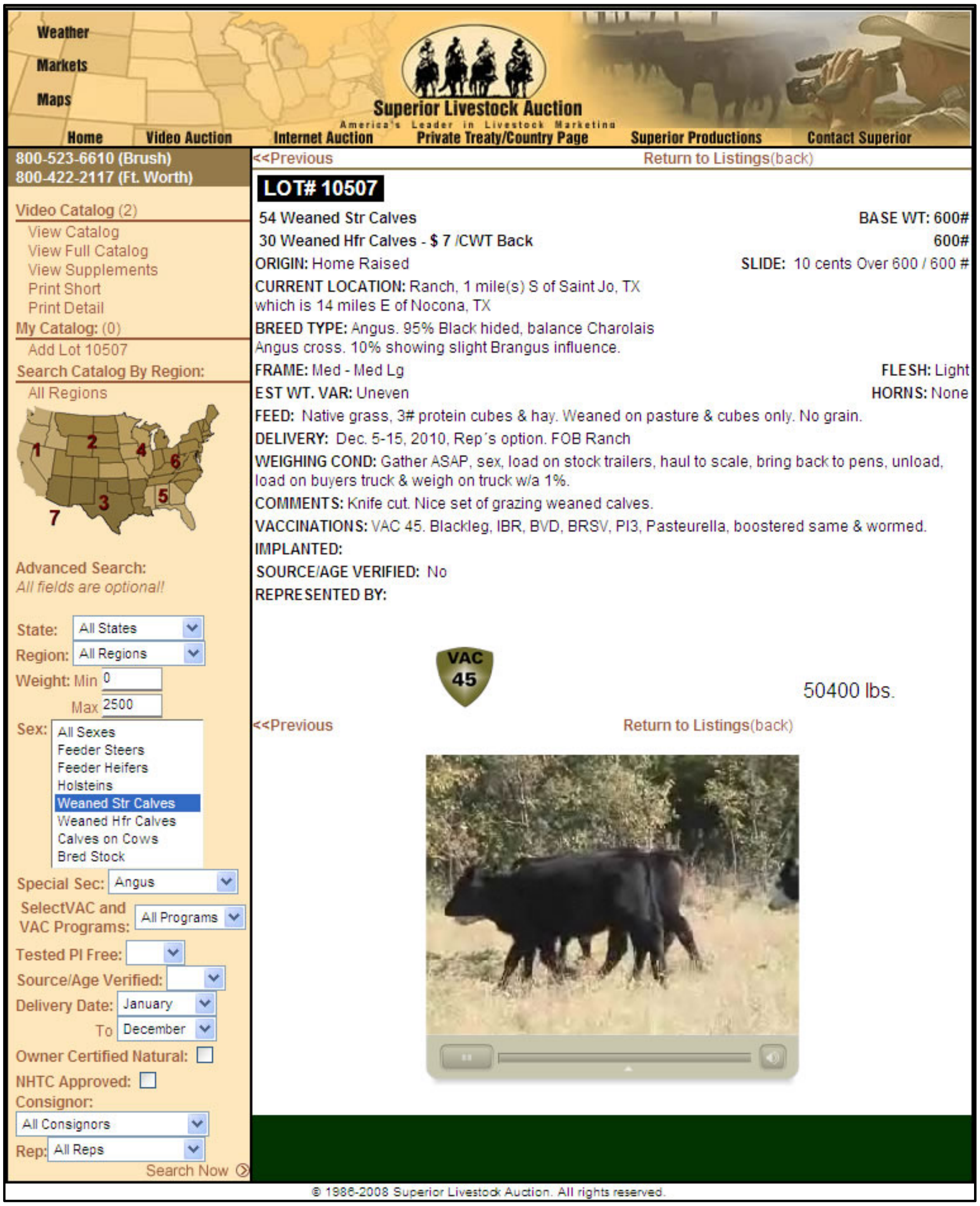
Superior Livestock Auction is the largest auction market in the United States. The video auction market sold more than 270,000 head in 1987 and grew to more than two million head marketed annually since 2001 (Bailey et al 1991, Bailey and Hunnicutt 2002, and Superior Livestock Auction 2010). The price and lot description information available from video auction markets provide an ideal source for hedonic pricing models. This chapter describes the SLA video auction market process as it pertains to the data analyzed. The discussion also reviews the database received from Pfizer Animal Health and the data organization process.

4.1 Description of Superior Livestock Auction Sales

Cattle can sell through three main formats at SLA – video auction, Internet auction or private-treaty Internet listings. The video auction markets are the focus of this study. Cattle are represented on SLA video auctions through a video and written lot description (Figure 4.1). A representative videotapes and photographs the cattle in their natural surroundings and works with the seller to prepare a consignment contract describing the cattle and outlining the sale terms and conditions. Contracts are sent to the company's Brush, Colorado, office for catalog development and further processing, and video is sent to a Fort Worth, Texas, office where it is edited into short clips for online preview and auction use (Superior Livestock Auction 2010).

The video auction catalog is made available on the Internet one week prior to the auction. Buyers and sellers can be present at the auction site on sale day, or they can view the auction through RFD TV, which is available through Dish Network and DirecTV direct-broadcast satellite services. Video of the cattle is shown while a live auctioneer calls for auction-site and telephone bids. The majority of SLA sales are cash forward contracts sold for future delivery. A contract is prepared stating the sale's terms and conditions once the cattle are sold. The sale representative contacts all parties to arrange delivery of the cattle and oversees sorting and loading. Cattle are shipped directly from the seller's ranch to the buyer's destination. The seller receives a check at delivery from an SLA bonded-custodial account, while the buyer pays for the cattle upon receipt (Superior Livestock Auction 2010).

Figure 4.1 - Superior Livestock Auction Video Market Written Lot Description (Seller and Representative Names Removed)



4.2 Data Sources

Pfizer Animal Health began collecting data on cattle sold through SLA video auction markets in 1995. The primary objective of the project was to measure the effect of SLA Value-Added Calf Protocols on video auction calf prices. Detailed information was collected on each lot to account for the influence of genetic, management and marketing characteristics on calf price. Data on cattle characteristics were obtained through the written descriptions of each lot featured in SLA sale catalogs, and lot price was acquired through published post-sale reports. The sales data were recorded each year and stored in a Microsoft® Access® database (King 2010).

The project has been maintained by the same Pfizer Animal Health employee since its inception more than 15 years ago. Previous feeder calf hedonic pricing studies have depended on data collected from a variety of sources and trained auction market evaluators. One of the advantages to this database is that lot descriptions have been analyzed and recorded using the same criteria for each sale. Human error is still a concern with this database. However, there should be a higher confidence level in the estimates derived from the SLA data relative to previous studies since the evaluation protocol was consistent across all lots of cattle.

The long-run nature of the project also captured the evolution of SLA and vertical coordination of the cow-calf sector through the information recorded. Traits such as year of study, sale number, auction date, number of cattle in the lot and gender have been recorded since the first year of the project. Other traits such as Natural-market eligibility, Non-Hormone Treated Cattle (NHTC) market eligibility and ASV were added to the database as they were recognized in SLA lot descriptions. Also, details pertaining to the breed or hide color of cattle were added as more information was provided in lot descriptions. Table 4.1 provides a summary of the characteristics accounted for in the database and the years they were included (King 2010).

Table 4.1 - List of Characteristics Recorded in the SLA Video Market Database

Characteristic class	Characteristic	Start year	End year
Lot	Year	1995	2009
	Sale number	1995	2009
	Lot ID number	1996	2009
	Sale price	1995	2009
	State of origin	1996	2009
	Region of origin	1995	2009
Genetic	Breed and/or color description	1995	2009
	90% or more black or black-white faced cattle	1999	2009
	90% or more Angus-influenced cattle	1999	2009
	Percentage of black-hided cattle	2000	2009
	Superior Progressive Genetics	2009	2009
	Presence of horns	1995	2009
	Frame score	1995	2009
Management	Average base weight	1995	2009
	Weight variation	1995	2009
	Flesh score	1995	2009
	Weaning status	1995	2009
	Calf or feeder status	1995	2006
	Home raised, purchased or combination	1995	2009
	Vaccination protocol administered	1995	2009
	Brand of vaccination protocol administered	2007	2009
	Haemophilus somni vaccination administered	2008	2009
	Moraxella bovis vaccination administered	2008	2009
	Implant protocol administered	1995	2009
	Brand of implant protocol administered	1995	2009
	Bovine Viral Diarrhea-Persistently Infected program	2008	2009
	Heifers - spayed status	1995	2007
	Heifers - Bangs vaccination status	1995	2005
	Heifers - Bangs vaccination status (con't)	2008	2009
Marketing	Auction date	1995	2009
	Delivery date	1995	2009
	Days between sale and delivery date	1995	2009
	Number of cattle	1995	2009
	Gender	1995	2009
	Weight price slide	1999	2004
	Shrink	1999	2004
	Certified Natural Cattle program	2004	2009
	Age-and-source verification program	2005	2009
	Brand of age-and-source verification program	2007	2009
	Non-Hormone Treated Cattle program	2008	2009

Mixed gender lots of cattle were not included in the database since heifer prices were calculated using a price slide based on the lot's steer sale price. The program began with the collection of all single gender calf and feeder cattle sales starting in June 1995. Data were collected on 20 to 25 sales annually through 2005. The volume of cattle sold through the SLA video market grew substantially during the first 10 years and sale lots described as feeder cattle, as opposed to calves, were not being utilized in company research. To optimize resources, Pfizer Animal Health made the decision to only record calf sale data from the six to eight largest calf sales starting in 2006. The data analyzed from 2006 to 2009 typically represents SLA video market sales from June through September of each year with calf delivery occurring mostly in the fall months (King 2010).

A number of characteristics have been added or dropped from the database since the start of collection. Sale lots of English cross cattle that were at least 90 percent black, black-white faced or Angus were identified as breed characteristics starting in 1999, and a new variable to account for the percentage of black-hided cattle in a lot was added in 2000. Calves that received two vaccinations against respiratory tract viruses and not enrolled in a value-added health program were identified starting in 2000. The Certified Natural Cattle program began in 2004, and a variable was added to the database to account for sale lots meeting program requirements. Similarly, cattle that were ASV were identified in SLA video market lot descriptions in 2005 and a variable was designated for these calves. In 2006, the first AngusSource® program calves were identified in the database, and all other ASV programs were identified in the database by brand name in 2007. The effect of bangs vaccinations on heifer sales price was not estimated in any of the previous Pfizer Animal Health studies, and the company decided to discontinue accounting for the variable in 2005. However, bangs-vaccinated heifers were again identified in the database starting in 2008. Superior Livestock Auction added the Pfizer Animal Health SelectVAC® preconditioning program to its Value-Added Calf Protocols in 2007, and these cattle were identified in the database (King 2010).

In 2008, the VAC 34+ health protocol was added as an SLA value-added health program and vaccination-protocol variable. Additionally, NHTC were added to the video market lot descriptions and identified in the database. New health identifiers were also added by SLA and to the database. These variables included vaccination variables for *Haemophilus somni* (*H. somni*) and *Moraxella bovis* (pinkeye), and a variable for calves that tested negative for being persistently infected with bovine viral diarrhea. Since only a small number of SLA heifer lots were spayed, it was decided to eliminate this variable from the SLA database as well. Superior Livestock Auction designated specific lots as Superior Progressive Genetics starting in 2009. The program was developed as a way for seedstock producers to differentiate quality of SLA bull sale offerings by identifying the top 45 percent of their sale bulls as Progressive Genetics. Commercial cow-calf producers who purchased these bulls and sold calves through SLA video markets could then list Superior Progressive Genetics as a part of their lot description (King 2010).

The SLA database did not account for variables that could accurately account for market conditions in a hedonic pricing model. Based on previous research on feeder cattle price differentials, additional market data were needed to account for these conditions. Chicago Mercantile Exchange (CME) futures market contract prices were obtained from the Livestock Marketing Information Center to improve the reliability of the hedonic pricing model. The 1995 to 2009 daily closing market prices for feeder cattle and No. 2 yellow corn monthly futures contracts were used in this analysis.

4.3 Description of Model Characteristics

The literature review of feeder cattle price determinants featured in Chapter 2 provided insight on how to refine the auction market databases to improve the reliability of resulting coefficient estimates. However, quantifying the auction market revenue generated from value-added management has become increasing complex as vertical coordination has reached the cow-calf sector. Many value-added programs that have evolved over the last 15 years demand a holistic management approach. These all-encompassing programs can create challenges in defining and modeling lot characteristics to determine the incremental value of each management practice. The primary research objective is to understand how management at the cow-calf level influences the price of calves sold through SLA video markets. The remainder of this section outlines how the characteristics in each database were refined to meet this goal. Traits are organized similar to Schultz et al. (2010) in lot, genetic, management, marketing and market structure characteristics.

4.3.1 Lot Characteristics

Sales prices were recorded in U.S. dollars per hundredweight for each lot that sold on SLA video markets from 1995 to 2009. The database also included lot descriptions for 15,903 sale lots that did not sell during the auction or were removed from the sale between catalog printing and sale day. Since the objective of the research was to look at the price determinants of various cow-calf management practices, no-sale observations were excluded from the analysis.

Year and region of origin were two lot characteristics incorporated into the hedonic pricing model to determine each attribute's influence on calf value. Sartwelle et al. (1996a) and Smith et al.

(2000) illustrated that year can be important in analyzing feeder calf price differentials. While the relative importance of statistically significant price determinants may remain unchanged from year-to-year, the magnitude of the price influence can vary considerably. The variables available in SLA lot descriptions also change from year to year. To accommodate these changes the database was stratified by specific multi-year ranges for each model. Ranges were determined based on the availability of lot, genetic, management and marketing characteristics over a particular timeframe and models were developed accordingly.

Observations from 1996 to 2009 included a state of origin for each lot sold within the contiguous United States. Regions were incorporated into the database similar to the classifications assigned by King et al (2006). A U.S. map illustrating the regions used in the research is featured in Figure 4.2. The West region included the states of California, Oregon, Washington, Idaho, Nevada and Utah. Colorado, Wyoming, Montana, North Dakota, South Dakota and Nebraska represented the Rocky Mountain/North Central region. The South Central region included Arizona, New Mexico, Texas, Oklahoma, Kansas, Missouri and Arkansas. Louisiana, Mississippi, Alabama, Florida, Georgia, South Carolina, North Carolina, Tennessee, Kentucky, Virginia and West Virginia were in the Southeast. The Midwest included Iowa, Minnesota, Wisconsin, Illinois, Indiana, Michigan and Ohio. Maryland, Delaware, Pennsylvania, New Jersey, New York, Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire and Maine were in the Northeast.

Total observations from the Midwest and Northeast regions combined represent less than one percent of the SLA database (Figure 4.3). The smaller number of observations would make it difficult to obtain a consistent and statistically significant price effect for cattle in these regions. Midwest and Northeast cowherds have distinct management and environmental differences compared to other regions making it difficult to combine these observations with another region. It is possible the smaller size of cow-calf operations in these regions makes it more difficult to assemble similarly managed truckload-sized lots of cattle to sell on SLA video markets. King et al. (2006) excluded lots from Midwest and Northeast states in their analysis due to the small number of observations. The same approach was used in this analysis. Data from the 1) West, 2) Rocky Mountain/North Central, 3) South Central and 4) Southeast regions were included in the analysis. Observations from 1995 did not have state-identifying information and thus were excluded from the model.

Figure 4.2 - Map of SLA Video Market Sale Regions Used in the Analysis

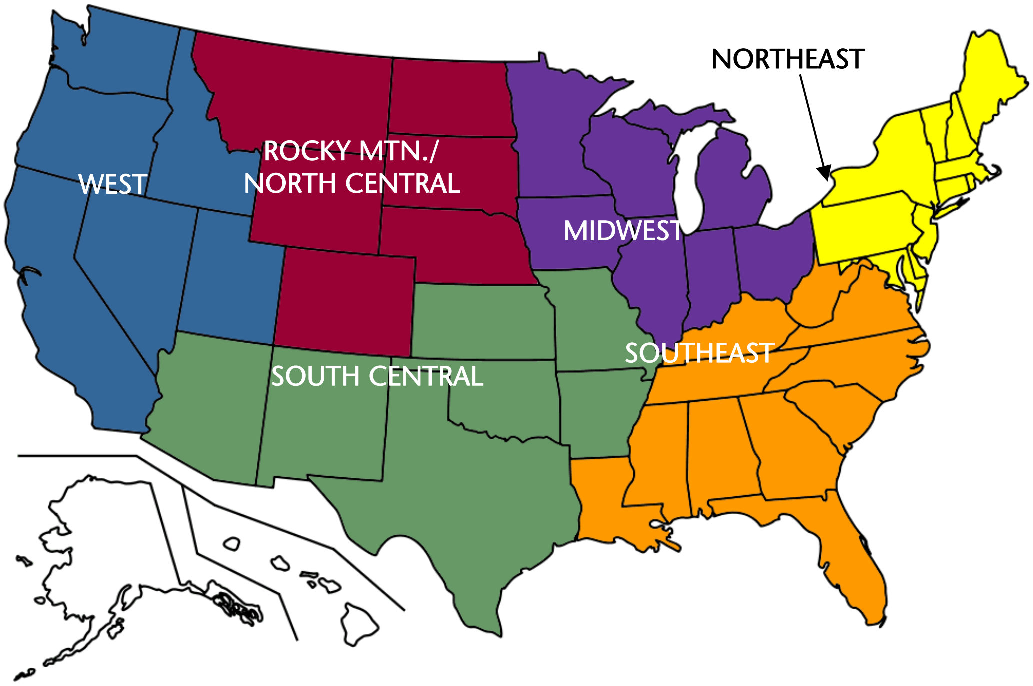
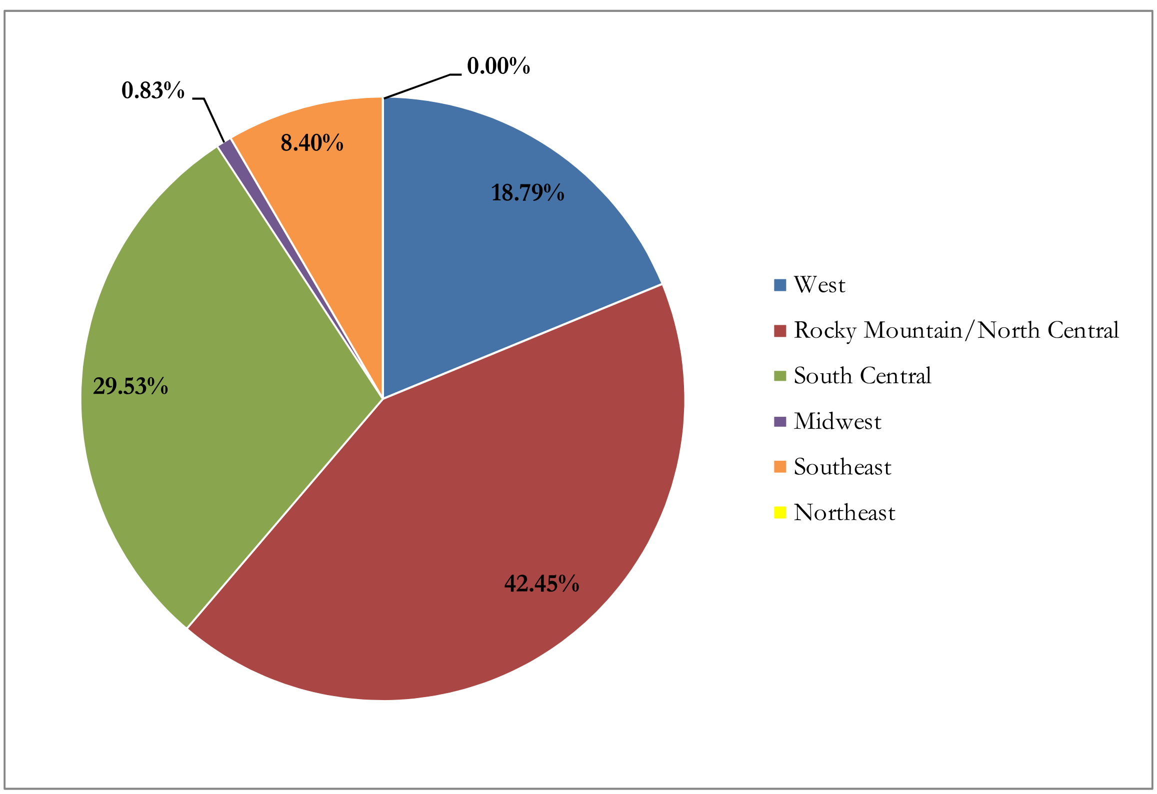


Figure 4.3 - Distribution of Region among SLA Calves, 1996 to 2009



4.3.2 Genetic Characteristics

Numerous variables were collected to account for the influence of genetic characteristics on sales price. These traits are influenced through genetic selection in the cowherd and are often measured by visual appraisal. Breed influence, presence of horns and frame size represented the most thoroughly analyzed genetic characteristics in the SLA database from 1995 to 2009 and were included in the hedonic pricing model. Dummy variables for 90 percent or more black-hide color and Angus influence presented potential collinearity issues with other breed variables due to overlapping physical characteristics and were not used in the models. A dummy variable for Superior Progressive Genetics lots was in the database starting in 2009. The characteristic was not incorporated in the research models since it was only listed in the last year of available lot information.

Breed influence has been modeled a variety of ways since the 1950s. Recent studies by Schultz et al. (2010), King et al. (2006) and Smith et al. (2000) each showed breed had a statistically significant influence on calf sale price. Buyers look at cattle breeds as an indicator for expected growth and carcass quality. Breed influence was defined through 21 different breed- and color-based variables provided through the SLA video market lot descriptions. To improve regression estimate accuracy, binary variables were developed for seven breed-influence categories: 1) Brahman and Brahman cross, 2) English and English cross, 3) Continental and Continental cross, 4) English-Continental cross, 5) black or black-white faced, 6) predominantly Angus and 7) predominantly Red Angus. At least 90 percent of a sale lot must have predominantly black-hide color and no Brahman influence to be classified as black or black-white faced. Likewise, lots characterized as predominantly Angus or Red Angus were described as containing at least 90 percent of the respective breed in the written description. Lots classified as English, Continental or English-Continental and their respective crosses included calves of that particular breed category with less than 90 percent black hided, Angus or Red Angus influence. Mexican-, Longhorn-, Corriente- and Dairy-influenced calves accounted for 0.3 percent of observations in the database. Calves from these breeds were excluded from the analysis due to the small number of observations, which is a difference in this study compared to studies from Smith et al. (2000), Lambert et al. (1989) and Schroeder et al. (1988).

The use of a black or black-white faced and predominantly Angus variable is unique to this hedonic model. Blank et al. (2006 and 2009) incorporated a Certified Angus Beef® candidate dummy variable in his analysis in addition to binary variables for English, Continental, Charolais and mixed breeds. However, with the exception of Schultz et al. (2010), existing hedonic models have rarely utilized both a hide color and Angus breed influence binary variable in the same regression. The majority of beef cattle breeds today feature some degree of black-hided influence in their registered populations. The Certified Angus Beef® brand was developed to create value for Angus genetics in vertically coordinated production systems. Differentiating between black-hided and Angus-influenced calves through separate binary variables will determine if premium differences exist between the two populations on the SLA video market.

The presence of horns is organized as a genetic characteristic in the data discussion, but horns can be managed through polled genetics or surgical removal. Discounts were applied to sale lots with horns in studies by Sartwelle et al. (1996a), Bailey et al. (1993), Lambert et al. (1989) and Schroeder et al. (1988). Past research and the SLA database did not differentiate between calves that were naturally or surgically polled and it is generally not a concern for feeder calf buyers. In general, order buyers prefer polled animals since they are easier to manage and present a lower risk for carcass bruises than horned animals. Horned status was tracked in the SLA database through binary variables for polled, horned, partially-horned and tipped-horn sale lots (Figure 4.4). One percent of calves were horned in the SLA database, and only five percent of calf sale lots included some horns. The horned characteristic was tracked through the use of a dummy variable in the database where one equals the presence of horns in the sale lot and zero represents an entirely polled group of calves.

Frame size is influenced by sire and dam genetics and is a general indicator for later feedlot performance and carcass weight. The characteristic was measured in SLA lot descriptions with eight different categories: 1) small, 2) small-medium, 3) medium, 4) medium to medium-large mix, 5) medium-large, 6) medium-large to large mix, 7) large, and 8) small, medium and large mix. A distribution for calf and feeder cattle frame size is in Figure 4.5. The scores were grouped into three variables representing frame size ranges for small to medium, medium to medium-large mix, and medium-large to large. These groupings are similar to research by Smith et al. (2000), Bailey et al. (1995) and Turner et al. (1993) and which used three different binary variables to differentiate frame size. In each study, larger frame size was positively correlated to higher calf prices.

Figure 4.4 - Distribution of Horns among Calves and Feeders, 1995 to 2009

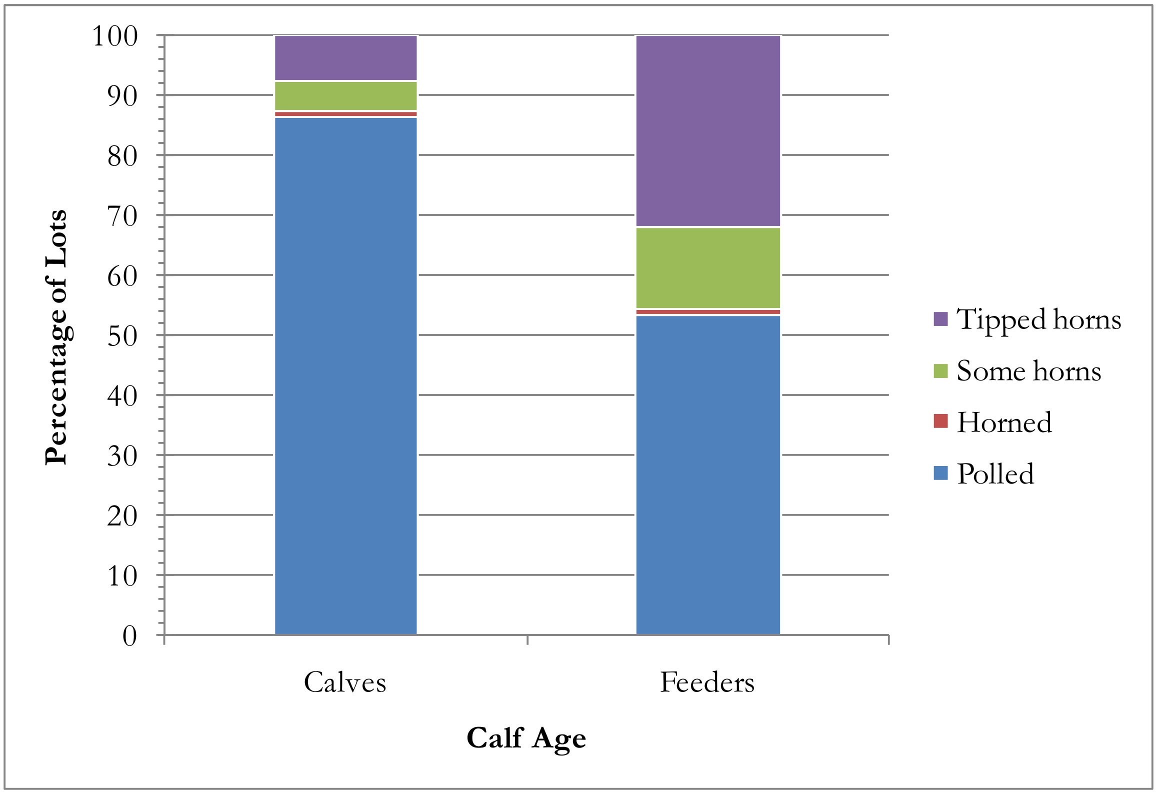
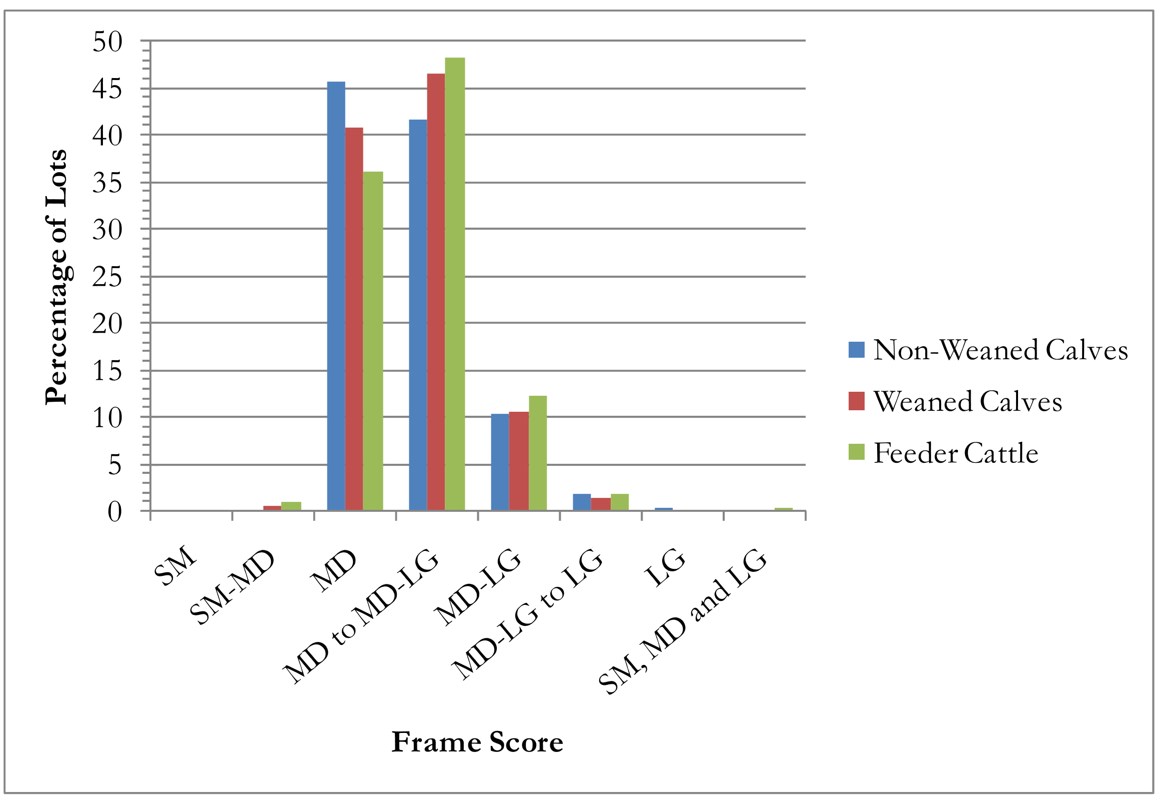


Figure 4.5 - Distribution of Frame Score in Calves and Feeder Cattle, 1995 to 2009



4.3.3 Management Characteristics

Cow-calf producers can also influence lot characteristics through nutrition and health management. Buyers will value calves based on how management characteristics affect expected calf performance, health and profitability in the backgrounding, stocker and feedlot sectors. Some characteristics are observed through visual appraisal while others are based on seller-provided information. The SLA lot description includes details on average base weight, weight variation, flesh score, weaning status, calf age, as well as vaccination and implant protocols.

Bailey et al. (1991) and Schroeder et al. (1988) highlighted the importance of stratifying feeder cattle auction market data based on gender, calf age and weight. The researchers said distinctly separate markets exist for calves and yearlings. Therefore, buyer preferences change based on calf age and weight. These differences are reflected in the varying price differentials for each group of cattle. The SLA database received from Pfizer Animal Health included 107,155 lots of cattle with average base weights ranging between 260 to 1,250 lbs. The database also included a variable for weaning status that combined aspects of calf age, weight and weaning by designating a sale group as non-weaned calves, weaned calves or feeder cattle (Figure 4.6 and Figure 4.7).

A June 21, 2010, phone conversation with Bill Broadie, an SLA representative in Kansas, clarified these lot characteristics. Broadie said feeder cattle sold through SLA must be weaned, and these cattle are considered yearlings in most cases. He stressed the designation is generally up to the SLA representative's interpretation, and average base weights for heavyweight calves and lightweight feeder cattle can overlap considerably. Broadie mentioned that 850 lbs. weaned calves in Kansas would generally be considered feeder cattle in SLA lot descriptions, even if the calves are not quite a year old. However, this same group of calves in California would likely be designated as weaned calves. The ambiguity of the description created a challenge in stratifying the dataset based on weight and age. The average base weight for each population was separated by around 200 lbs., but weight ranges for calves and feeder cattle were similar (Table 4.2).

Figure 4.6 - Weight Distribution of Steer and Heifer Calves, 1995 to 2009

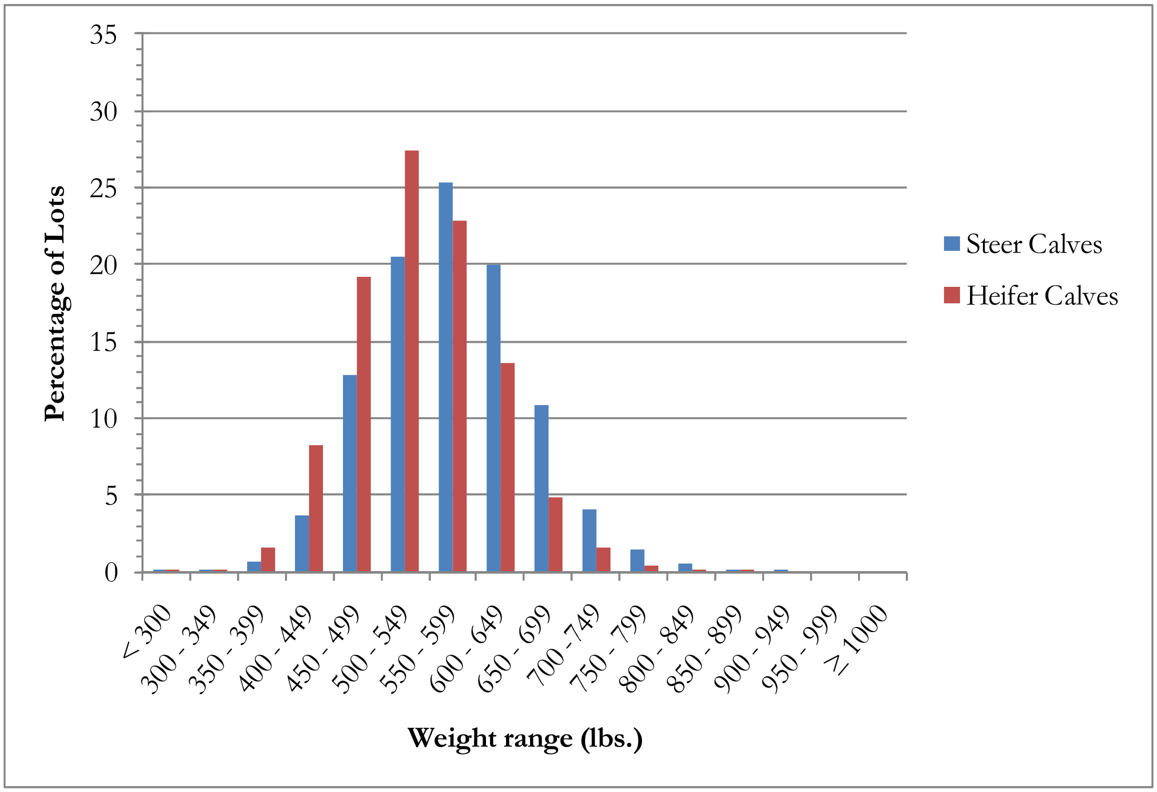


Figure 4.7 - Weight Distribution of Feeder Steers and Heifers, 1995 to 2009

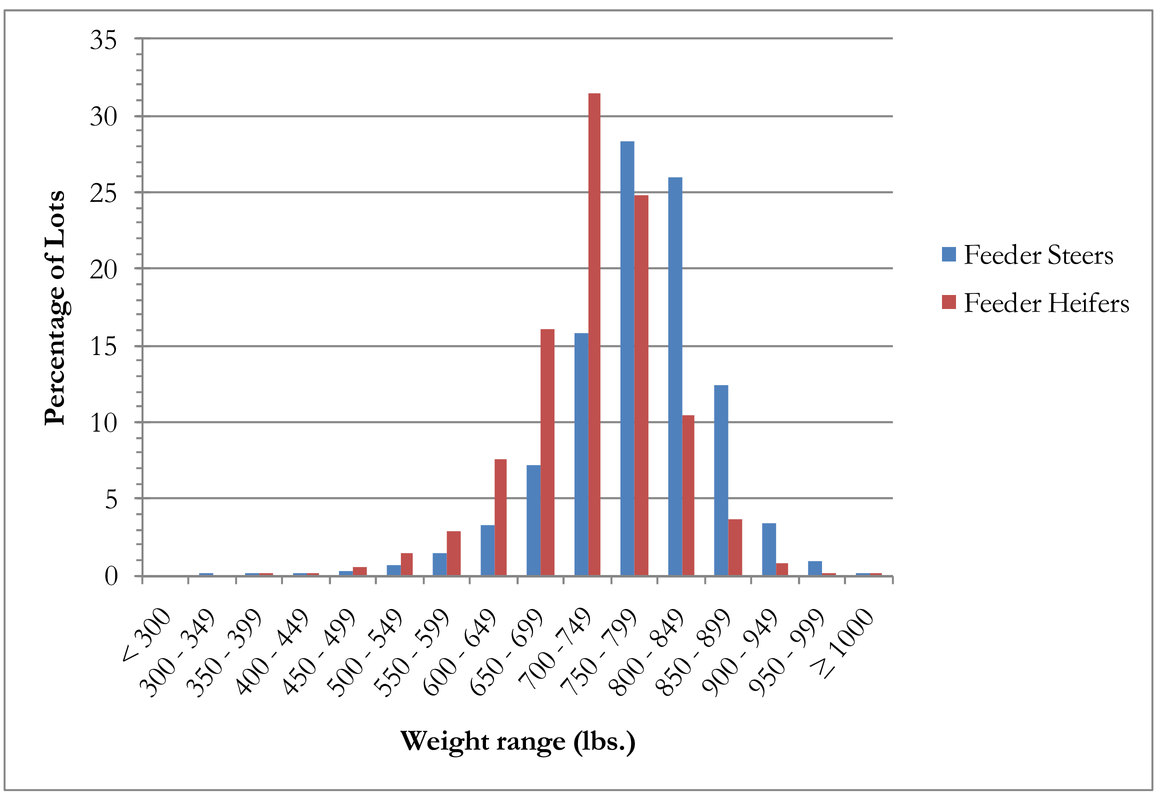


Table 4.2 - Average Weight, Lot Size and Sale Price by Calf Age, 1995 to 2009

Gender	Mean variable	Feeder Cattle				Calves			
		Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum
Steers	Base weight (lbs.)	773.72	78.01	335	1085	569.50	78.64	275	925
	Lot size (# of head)	127.72	114.72	15	2700	123.41	78.08	20	1165
	Sale price ($ per cwt.)	$71.16	34.44	$0.00	$157.00	$91.39	39.47	$0.00	$183.00
Heifers	Base weight (lbs.)	722.98	74.37	375	1250	534.24	72.16	260	850
	Lot size (# of head)	120.56	100.99	26	2880	116.12	67.46	20	1150
	Sale price ($ per cwt.)	$65.89	34.64	$0.00	$131.50	$83.17	39.32	$0.00	$167.00

Feeder cattle represent a population that is generally one step removed from the cow-calf sector's management influence. Also, Pfizer Animal Health last recorded feeder cattle observations in 2006. These challenges led to the exclusion of feeder cattle from the research model to adhere to the research objectives. The calves remaining in the database had a weight range of 650 lbs. Similar to Blank et al. (2006 and 2009), a narrower weight range was selected to make price comparisons among more biologically similar cattle and improve the reliability of the hedonic model estimates. The new weight range for steers was 450 to 750 lbs., and the heifer weight range was 400 to 700 lbs.

Schultz et al. (2010), Blank et al. (2006 and 2009) and Schroeder et al. (1988) found that weight variation was a statistically significant price determinant in feeder calf markets. In general, producers can expect to receive a price premium for increased weight uniformity. Lots with more even weight distributions offer greater convenience to backgrounding, stocker and feedlot operators who prefer to manage cattle that are physiologically similar in age. Weight variation within SLA sale lots was measured using four descriptions: even, fairly even, uneven and very uneven. Nearly 90 percent of lots were described as having uneven weights, and less than one percent of lots were considered even. Lots characterized with even and fairly even weight variation were grouped in the same category and three binary variables were used to identify weight variations on SLA lot descriptions: 1) even to fairly even, 2) uneven and 3) very uneven. Flesh amount was characterized similarly to frame size on SLA lot descriptions. Seven characteristics were used to quantify flesh amount: 1) light, 2) light-medium, 3) light-medium to medium mix, 4) medium, 5) medium to medium-heavy mix, 6) medium-heavy and 7) heavy. Medium flesh scores were given to more than 80 percent of all calves and feeder cattle sold in the SLA video market (Figure 4.8). Three binary variables were used in the pricing model to account for calves with 1) light to light-medium and light-medium to medium mix, 2) medium and 3) medium to medium heavy mix and heavy flesh scores.

Origin or lot makeup was also quantified in SLA lot descriptions for home-raised, purchased and mixed lots of cattle. Hedonic pricing models in previous research have not explored the effect of origin on feeder calf prices. A dummy variable for entirely home-raised sale lots was considered for estimation in the research model. Figure 4.9 shows the weaning strategy for home-raised calves compared to other lots of cattle.

Accounting for the price effect of weaning and vaccination protocols has became more complicated with the industry adoption of value-added calf (VAC) protocols. Promoted through the Texas A&M Ranch to Rail Program, these preconditioning practices are recognized in the beef industry for their combination of vaccination, weaning and parasite management practices. King et al. (2006) was one of the first published studies to look at the effect of different VAC protocols on calf price. Studies by Blank et al. (2006 and 2008) and Kellom et al. (2008) estimated the price effect of different individual components of preconditioning protocols and showed a statistically significant price influence for weaned and preconditioned calves. Smith et al. (2000), Sartwelle et al. (1996a) and Schroeder et al. (1988) showed that premiums existed for healthier appearing calves, and research by Dhuyvetter et al. (2005) and Lalman and Smith (2001) used hedonic models to reveal preconditioned calves brought more than non-preconditioned calves. The VAC protocols recognized by SLA are described in the review of King et al. in Chapter 2 and are summarized in Table 4.3 and Table 4.4.

Figure 4.8 - Distribution of Flesh Score in Calves and Feeder Cattle, 1995 to 2009

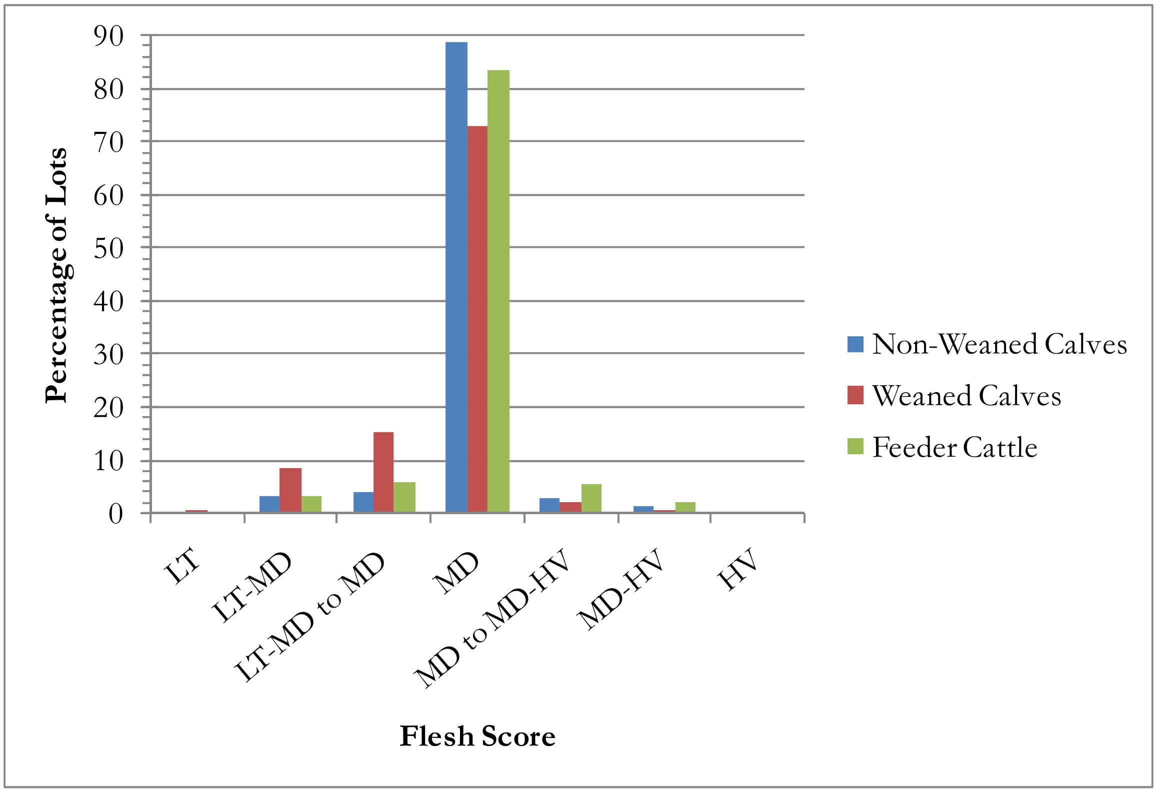


Figure 4.9 - Calf Origin and Weaning Strategy, 1995 to 2009

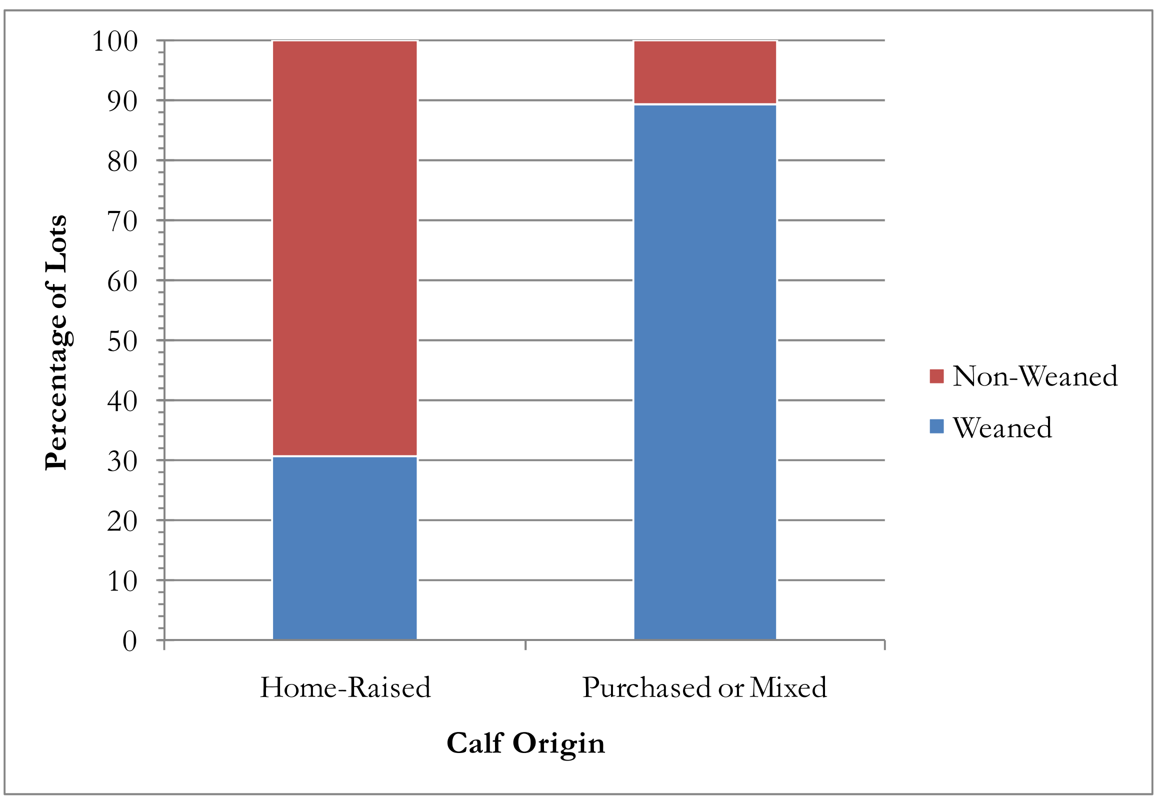


Table 4.3 - Non-Weaned Calf VAC Protocols for the SLA Video Market

Value-Added Calf Protocol	Management Requirements	Timing
VAC 24	Vaccinated against: ● IBR and PI3* ● BVD and BRSV** ● *Mannheimia haemolytica* and/or *Pasteurella multocida**** ● Clostridial 7-way ● Parasite control (optional)	Calves are vaccinated on cows at 2 to 4 months of age.
VAC 34	Vaccinated against: ● IBR and PI3 ● BVD and BRSV ● *Mannheimia haemolytica* and/or *Pasteurella multocida* ● Clostridial 7-way ● Parasite control (optional)	Calves are vaccinated on cows 2 to 6 weeks prior to shipping.
VAC 34+	First-round vaccinated against: ● IBR and PI3 ● BVD and BRSV ● Clostridial 7-way Second-round vaccinated against: ● IBR and PI3 ● BVD and BRSV ● *Mannheimia haemolytica* and/or *Pasteurella multocida* ● Clostridial 7-way ● Parasite control (optional)	Calves are first-round vaccinated at branding and receive booster vaccinations 2 to 6 weeks prior to shipping.

*** IBR and PI3 vaccines must be chemically altered modified live or modified live with veterinarian approval, killed vaccines are not acceptable**

**** BVD and BRSV vaccines can be killed or modified live**

***** *Mannheimia haemolytica* and/or *Pasteurella multocida* vaccines must contain leukotoxoid component**

Table 4.4 - Weaned Calf VAC Protocols for the SLA Video Market

Value-Added Calf Protocol	Management Requirements	Timing
VAC 45 (option 1)	Pre-weaning: first-round vaccinated against: ● IBR and PI3* ● BVD and BRSV** ● *Mannheimia haemolytica* and/or *Pasteurella multocida**** ● Clostridial 7-way Weaning: second-round vaccinated against: ● IBR and PI3 ● BVD and BRSV ● *Mannheimia haemolytica* and/or *Pasteurella multocida* ● Clostridial 7-way ● Parasite control (optional)	Calves are first-round vaccinated 2 to 6 weeks prior to weaning and receive booster vaccinations at weaning. Calves are weaned at least 45 days prior to shipping.
VAC 45 (option 2)	Pre-weaning: first-round vaccinated against: ● IBR and PI3 ● BVD and BRSV ● *Mannheimia haemolytica* and/or *Pasteurella multocida* ● Clostridial 7-way Weaning: second-round vaccinated against: ● IBR and PI3 ● BVD and BRSV ● *Mannheimia haemolytica* and/or *Pasteurella multocida* ● Clostridial 7-way ● Parasite control (optional)	Calves are first-round vaccinated at weaning and receive booster vaccinations according to vaccine label instructions. Booster vaccines must be given at least 14 days prior to delivery. Calves are weaned at least 45 days prior to shipping.
VAC Precon	Pre-weaning: first-round vaccinated against: ● IBR and PI3 ● BVD and BRSV ● *Mannheimia haemolytica* and/or *Pasteurella multocida* ● Clostridial 7-way Weaning: second-round vaccinated against: ● IBR and PI3 ● BVD and BRSV ● *Mannheimia haemolytica* and/or *Pasteurella multocida* ● Clostridial 7-way ● Parasite control (optional)	Designated for calves from various sources. Calves are first-round vaccinated at arrival and receive booster vaccinations according to vaccine label instructions. Booster vaccines must be given at least 14 days prior to delivery. Calves are weaned at least 60 days prior to shipping.

*** IBR and PI3 vaccines must be chemically altered modified live or modified live with veterinarian approval, killed vaccines are not acceptable**

**** BVD and BRSV vaccines can be killed or modified live**

***** *Mannheimia haemolytica* and/or *Pasteurella multocida* vaccines must contain leukotoxoid component**

The database included the SLA vaccination protocols as binary variables. Also, vaccinated cattle not meeting specific VAC requirements were designated as receiving a complete vaccination program, one vaccination or two vaccinations. A time was also noted in the database for non-VAC protocol vaccinations when the details were available. Separate variables also accounted for branded vaccination programs including Merial® SureHealth® and SelectVAC® programs. The database also recorded non-vaccinated cattle and a small number of calves vaccinated against *Mannheimia* *haemolytica* and/or *Pasteurella multocida*. The database also noted sale lots that tested negative for being persistently infected with BVD and included dummy variables for lots vaccinated against *Haemophilus somni*, pinkeye and bangs in heifers.

Based on the database characteristics, eight variables accounted for calf respiratory vaccination program in the hedonic model: 1) No respiratory vaccination or weaning, 2)VAC 24, 3) VAC 34, 4) VAC 34+, 5) VAC 45, 6) VAC Precon, 7) One respiratory vaccination and 8) Multiple respiratory vaccinations. The five SLA vaccination protocols were included as variables in the model, and calves not meeting the protocol were designated as receiving one, multiple, or no respiratory vaccinations. Vaccination program brand names were identified in three percent of all observations and were considered the same as non-branded vaccinations in the model. The smaller number of branded vaccination observations would make it difficult to get consistent and statistically significant estimates for this price effect that could be confidently supported by the research.

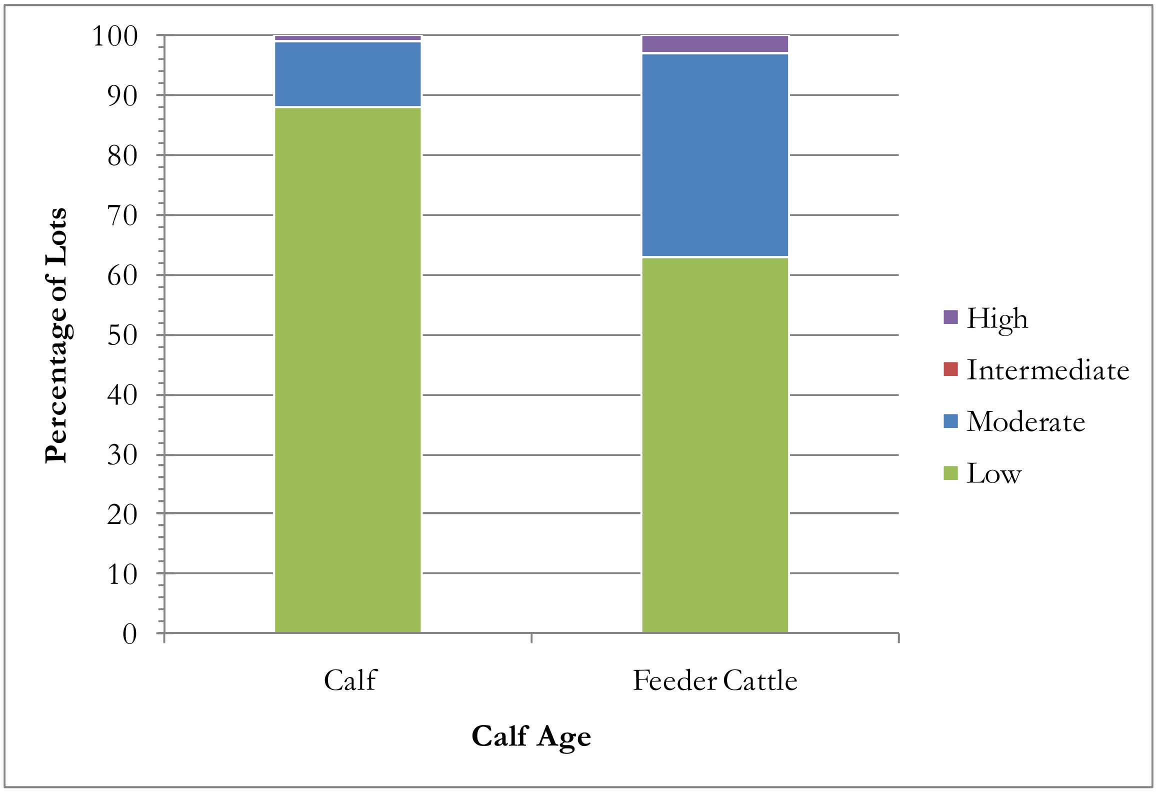
The model also excluded variables for respiratory vaccination timing on non-VAC protocol calves and vaccinations for *Mannheimia haemolytica* or *Pasteurella multocida*. It was assumed that vaccination timing was not as critical as the respiratory vaccination itself, and the number of lots only vaccinated for *Mannheimia haemolytica* and *Pasteurella multocida* was relatively small compared to the other vaccination options. The model did include dummy variables to account for calves that tested BVD-PI negative or received *Haemophilus somni*, pinkeye and bangs vaccinations. The first three variables were added to SLA sale catalogs in 2008. There was interest to see if these programs had a statistically significant effect on price after two years of buyer familiarity. Bangs vaccinations were included in lot descriptions over the duration of the database project. Brucellosis vaccinations are generally reserved for higher quality heifers raised with the intent to be purchased and bred as herd replacements. The price effect of bangs vaccination will determine if buyers perceive these animals as higher quality at the SLA video market.

Separating the price effect of weaning in the presence of VAC protocols can be a challenge due to the combined influence of vaccinations and weaning in these protocol. Existing research has not sufficiently separated these price effects while analyzing the value of preconditioning. King et al. (2006) eliminated weaned calves that did not meet VAC 45 or VAC Precon health protocols to avoid confounding effects between weaning and vaccination program effects in the pricing model. Blank et al. (2006 and 2009) found statistically significant premiums for weaning and preconditioning. However, the research did not reveal defined preconditioning standards or look at price effects of different vaccination programs. The SLA protocols for VAC 24, VAC 34 and VAC 34+ do not require weaning, and producers gravitate toward these programs to benefit from third-party certification without weaning calves. Therefore, few observations in the database were weaned and considered candidates for these programs. When cow-calf producers wanted a VAC protocol for their weaned calves, they would instead manage them to meet VAC 45 or VAC Precon requirements. However, both weaned and non-weaned calves were well represented among observations vaccinated for respiratory diseases and not in a certified health program. Similarly, very few non-vaccinated calves were also weaned. Based on these interactions, a variable was added to the model to account for the price effect of weaning on calves that received respiratory vaccinations not certified through SLA.

The evolution of natural and NHTC markets over the last 10 years has linked feeder calf price differentials for these marketing characteristics with implant management at the cow-calf level. To participate in each of these vertically coordinated programs, cattle are prohibited from receiving growth hormones. Depending on the program other management requirements also apply. These programs have the potential to enhance the value of non-implanted calves and will be discussed in greater detail in the marketing characteristics section.

Three studies have evaluated the effect of implants and natural production standards on calf sale prices. The price determinants for implants and natural production were evaluated in studies by Blank et al. (2006 and 2009), and King et al. (2006) evaluated the price effects of natural production. In addition to an implant variable, brand of implants were known for 93 percent of implanted sale lots in the SLA database. Christopher Reinhardt, Kansas State University assistant professor and feedlot extension specialist, analyzed the implant-brand data and provided a breakdown of implant protocols based on low, moderate, intermediate and high potency. Higher implant potencies translate to greater growth capabilities under the right genetic and nutritional environment. A percentile breakdown of implant potency is provided in Figure 4.10. Nearly 90 percent of calves with known implant brands received a low-potency implant. The small amount of variation among implant protocols resulted in one variable for completely implanted sale lots. Another variable accounted for partially implanted lots and lots where the written description did not specify implant use.

Figure 4.10 - Distribution of Known Implant Potency in Calves and Feeder Cattle, 1995 to 2009



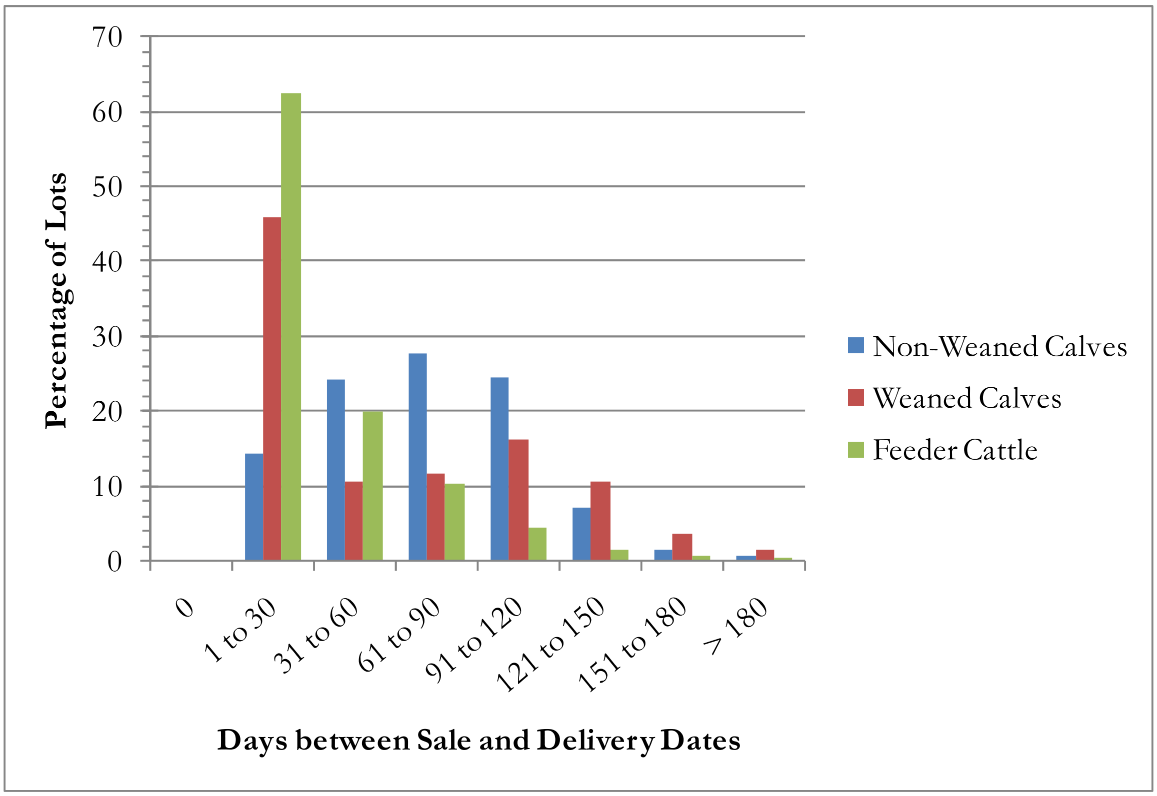
4.3.4 Marketing Characteristics

Traits that influence the marketability of calves on SLA video markets and participation in vertically coordinated markets are considered marketing characteristics in the hedonic pricing model. Sale date, delivery date, lot size, gender and shrink can affect buyer preferences for a group of calves. Furthermore, participation in natural, NHTC and ASV programs can expand the marketing options for calves in proceeding sectors. Some marketing characteristics are dictated by sale date, while others are realized through previous management and written lot descriptions.

Previous research has utilized video market sale and delivery dates differently in feeder calf pricing models. Blank et al. (2009) evaluated the influence of changing sale and delivery months on calf price and found each variable significant at the 90 percent confidence level. Superior Livestock Auction sales are typically multiple-day events. King et al. (2006) utilized each sale as a dummy variable to account for seasonality in the market and also looked at how the difference in days between sale and delivery date influenced price. Bailey et al. (1993) utilized sale date in a similar manner to Schroeder et al. (1988) and developed quarterly dummy variables to account for market seasonality. The approach of King et al. (2006) offered opportunities to further examine the price effects of forward contracting.

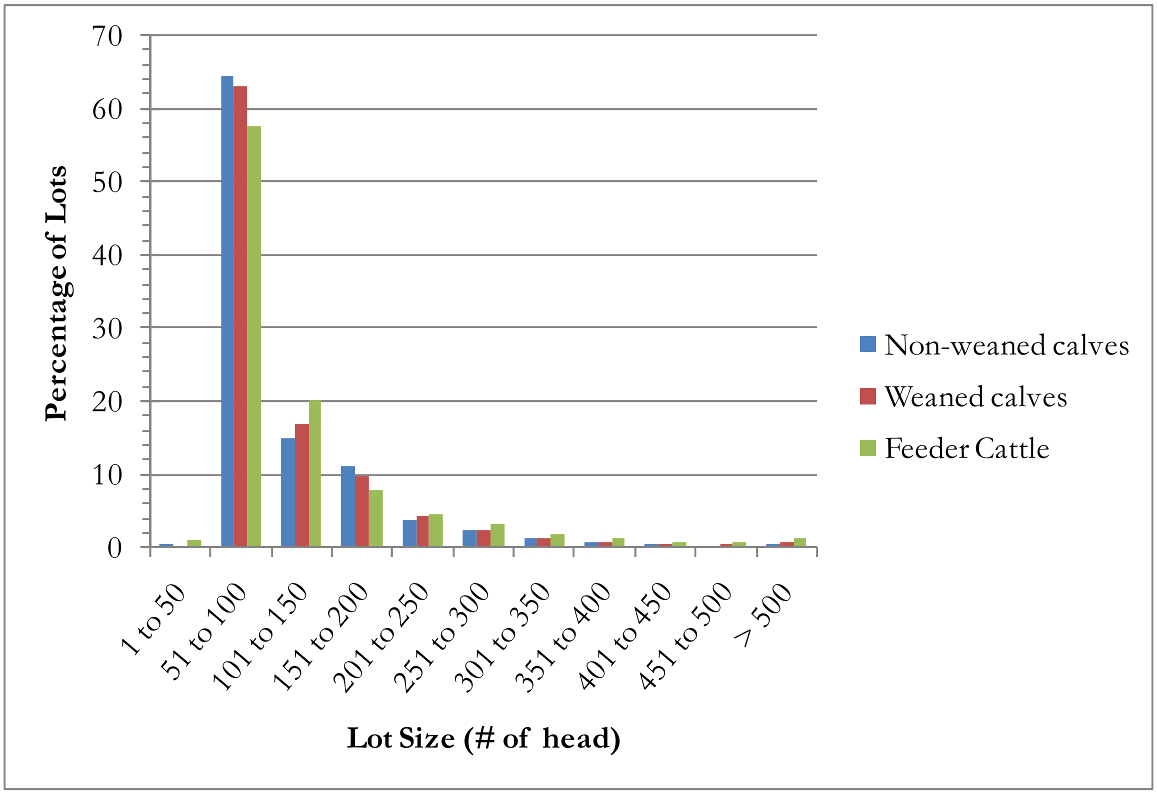
A variable was added to the analysis to account for the days between sale and delivery to examine how price risk affects calf prices at SLA video market. The majority of calves were delivered within three months of the sale day, while more than 60 percent of feeder cattle lots were delivered in the first 30 days following the sale (Figure 4.11). Around 0.10 percent of all cattle were delivered on the day of the sale. Less than 0.1 percent of calves were sold more than six months in advance of delivery. It was assumed that cattle sold more than six months prior to delivery would be more susceptible to price variations due to buyer error. These observations were excluded from the hedonic pricing model.

Figure 4.11 - Distribution of Days between Sale and Delivery Dates for Calves and Feeder Cattle, 1995 to 2009



Lot size has been included in feeder cattle hedonic models since 1961 (Williamson et al.). Twenty five years later, Faminow and Gum (1986) suggested that lot size had a non-linear influence on price. Models since then have adopted that approach to estimating lot size price determinants. Research by Avent et al. (2004), Bailey et al. (1993 and 1995) and Schroeder et al. (1988) has continued to find lot size positively affects price at a decreasing rate as lot size increases. Lot size was recorded for each group of calves in the SLA database with an average lot size of 125 head and a range from 15 to 2,880 head (Figure 4.12). To determine if lot size has a non-linear relationship to price, the modeling approach of Faminow and Gum was utilized in this study. Variables to account for lot size and lot size squared were included in the analysis.

Figure 4.12 - Distribution of Lot Size in Calves and Feeder Cattle, 1995 to 2009



Two primary methods for estimating the effect of gender on calf prices have been used in previous literature. Schultz et al. (2010) and Faminow and Gum (1986) evaluated gender within the same pricing model and documented the variation in weight-price relationships across gender. Bailey et al. (1993) and Schroeder et al. (1988) argued that cattle markets differ based on the cattle gender and weight. The economists said that models based on databases separated by weight (lightweight and heavyweight) and gender (steers and heifers) capture the varying preferences of buyers across different classes of cattle. Referenced in Section 4.4.4, the database was separated based on the later argument. Separate models were analyzed for 450- to 750-lbs. steers and 400- to 700-lbs. heifers.

Weight-price slide and pencil shrink are tools used in feeder cattle forward-contract arrangements to reduce the weight risk experienced by buyers. Superior Livestock Auction lot descriptions express the weight-price slide as a cent-per-pound discount applied when lots exceed the expected average base weight. Pencil shrink is listed as a percentage of weight loss for calves shipped to the buyer's location. The percentage is deducted from the average base weight to determine the final sale weight and lot price. The hedonic pricing model developed by Bailey et al.

(1993) utilized a ratio of the allowable weight variance in the lot and the price slide amount to estimate the effect of weight risk on calf prices. The research found that weight risk had a statistically significant influence on price. As buyers were exposed to more weight risk, the price offered for calves decreased. Weight-price slide and pencil shrink data were available for lots of cattle that sold from 1999 to 2004. Since the data was not available for all sale lots, variables to capture these effects were excluded from the model.

Age-and-source verified calves have commanded statistically significant premiums in research by Blank et al. (2009), Kellom et al. (2008) and King et al. (2006). Sale lots identified as being ASV include ranch of origin information in addition to details on the first and last birth date of calves in the group. Age-and-source verification systems require each calf to use a program-specific individual-identification tag. Producers must pay enrollment fees that generally cover RFID tag, administration and database costs. Exact costs can vary considerably depending on program details (Barnham 2007). Potential sale premiums are generated based on the additional beef export marketing opportunities that are available for calves enrolled in ASV programs. The SLA database included lot information on ASV beginning in 2005. Starting in 2007, Pfizer Animal Health also recorded details on the ASV brand name or provider. Age-and-source verification is monitored through companies or organizations with a USDA Process Verified Program (PVP) or Quality Systems Assessment (QSA), and each ASV program must adhere to the same standards for minimum compliance. Some programs might offer additional verification services as a component of ASV (Barnham 2007). For instance, AngusSource® also verifies Angus sire parentage and Montana Beef Network verifies a Montana origin (AngusSource 2009 and IMI Global 2010a). However, the primary benefit for each ASV is export verification. To capture this price effect, a single dummy variable was used in the model to represent calves that were ASV.

Superior Livestock Auction started the Certified Natural Cattle program in 2004 and the Non-Hormone Treated Cattle program in 2008 (King 2010). Each program's requirements are summarized in Table 4.5. Producers managing cattle for a natural market are faced with more feed and antibiotic-use requirements. However, non-implanted cattle, without natural-market certification, can be purchased for natural production if a buyer can verify ranch-level management practices. The requirements for NHTC markets are more stringent and require the ranch to be approved for production before cattle leave the operation. Once a ranch is approved for NHTC production, calves from the ranch are eligible for the European Union export market (IMI Global 2010b). The requirements for each program differentiate the value of non-implanted calves on SLA video markets. To estimate the price effect of these programs, three variables were developed for 1) non-implanted, 2) natural non-implanted and 3) NHTC non-implanted calves.

Table 4.5 - Description of SLA Video Market Natural and NHTC Program Requirements

Beef Program	Management Requirements	Documentation
Certified Natural Cattle	Ranch of origin must be certified by a USDA Quality Systems Assessment program Cattle must be age-and-source verified Cattle are prohibited from receiving: ● Ionophores ● Antibiotics and/or sulfas that were fed or injected ● Growth promoting hormones/steroids that were fed, given orally or injected ● Beta Adrenoceptor-agonist that was fed or injected ● Any type of animal by-product in feedstuffs, mineral supplements or feed tubs	Producer must complete and sign an affidavit concerning the program's management requirements. The seller must be the original owner of the cattle or supply a signed "all natural" certificate from the original owner. Animals that receive therapeutic treatment must be individually identified and not shipped without buyer permission.
Non-Hormone Treated Cattle	Ranch of origin must be certified by a USDA Quality Systems Assessment program Cattle must be age-and-source verified Cattle are prohibited from receiving: ● Growth promoting hormones/steroids that were fed, given orally or injected ● Beta Adrenoceptor-agonist that was fed or injected ● Melengestrol acetate (MGA) that was fed	Producer must complete and sign an affidavit concerning the program's management requirements. Calves must be individually identified and recordkeeping must verify the animals origination, nutrition and health management programs. Calves also must be sourced from an approved premises with appropriate documentation to be eligible for the program.

4.3.5 Market Conditions

Research from Schroeder et al. (1988) and Marsh (1985) was among the first to use feeder cattle and corn futures market contract prices as proxy variables to represent current market conditions in feeder calf pricing models. Bailey et al. (1993 and 1995) and Turner et al. (1993) replicated this approach with the use of feeder cattle futures in the analysis of electronic feeder cattle market prices. Each study showed that futures market conditions statistically influenced the price of feeder cattle. As mentioned in the previous section, sale dates have also been used as a variable to capture the effect of seasonality and current market conditions on price.

It is assumed that the CME futures markets for feeder cattle and corn are efficient. Therefore, the market reflects all relevant supply and demand factors that would affect general feeder calf and corn market prices on a given day. Based on this assumption the use of feeder calf futures provides a mechanism for defining the long-run variation within feeder calf markets. Corn futures market contract prices can be used in the model to define the buyer expectations for the cost of gains in raising feeder calves to a finished weight.

Futures market prices provide a more intuitive explanation to forecast market conditions than individual sale dates or time-trend variables for the purpose of this analysis. A research priority is to provide the beef industry with a clear analysis on the price effects of value-added management at the cow-calf level. It is difficult to casually interpret how market forces cause prices on one sale day to be higher or lower than the next. The industry is more familiar with the daily behavior of feeder cattle and corn futures contract prices. This foundation provides a more logical account for the influence of futures markets on feeder calf prices compared to day-to-day sale price variations. The coefficient estimates for each proxy variable can also provide an indication for how efficient SLA video markets are in reflecting national market behaviors in feeder calf prices. These estimates can be applied by producers along with the model's other coefficient estimates to forecast an approximate value for their calves.

Chicago Mercantile Exchange daily closing futures market contract prices for feeder cattle and No. 2 yellow corn were obtained from the Livestock Marketing Information Center. The closing feeder cattle and corn futures contract prices for the market day prior to each SLA sale day were used for the analysis. The feeder cattle futures price associated with each observation represented the nearby contract to the delivery date, while corn contract prices were lagged based on the weight of calves.

4.4 Summary of Empirical Data Source

The hedonic pricing model estimated in this study will use the database summarized in Table 4.6 and Table 4.7. It includes 53,612 lots of calves sold through SLA video market sales from 1996 to 2009 that were delivered to buyers within six months of sale day. The database includes 31,655 steer lots with average base weights of 450 to 750 lbs. and 21,957 heifer lots weighing 400 to 700 lbs. The analysis did not include observations without prices, frame scores, flesh scores or weight variation scores. Calves from Midwestern or Northeastern states were removed from the database. Mexican- , Longhorn- , Corriente- and Dairy-influence calves were also excluded. The research did not look at the price effects of small, medium and large frame mixed lots of cattle. Calves that only received non-respiratory vaccinations and weaned VAC 24, VAC 34 and VAC 34+ cattle were also removed from the analysis.

Table 4.6 - Average Price, Lot, Weight, Sale and Delivery Data for the Analyzed SLA Video Market Database, 1996 to 2009

Mean variable	Steers - 450 to 750 lbs.				Heifers - 400 to 700 lbs.			
	Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum
Sale price ($ per cwt.)	$105.77	19.86	$41.25	$183.00	$99.03	19.14	$39.35	$167.00
Nearby feeder cattle futures contract ($ per cwt.)	$94.78	16.16	$51.82	$119.48	$94.04	16.03	$51.82	$119.48
Lot size (# of head)	123.62	77.15	20	1165	116.07	66.89	20	1150
Base weight (lbs.)	569.17	78.35	275	925	533.58	71.36	265	850
Sale month (# of month)	7.14	2.09	1	12	7.00	2.29	1	12
Delivery month (# of month)	9.33	2.48	1	12	9.10	2.75	1	12
Days to delivery (days between sale and delivery)	68.23	42.87	0	180	66.05	44.10	0	180

Table 4.7 - SLA Video Market Database Means, 1996 to 2009

Characteristic	Variable description	Steers - 450 to 750 lbs. Observations (# of lots)	(% of lots)	Heifers - 400 to 700 lbs. Observations (# of lots)	(% of lots)
Frame	Small to medium	13508	42.67%	9888	45.03%
	Medium to medium-large Mix	13962	44.11%	9629	43.85%
	Medium-large to large	4185	13.22%	2440	11.11%
Flesh	Light to light-medium	1554	4.91%	1248	5.68%
	Light-medium to medium mix	2393	7.56%	1948	8.87%
	Medium	26603	84.04%	18108	82.47%
	Medium to medium-heavy mix to heavy	1105	3.49%	653	2.97%
Weight variation	Even to fairly even	2227	7.04%	1296	5.90%
(uniformity)	Uneven	28293	89.38%	19724	89.83%
	Very uneven	1135	3.59%	937	4.27%
Implant	Not implanted	13123	41.46%	11339	51.64%
	Natural eligible - Not implanted	4542	14.35%	3013	13.72%
	NHTC eligible - Not implanted	82	0.26%	77	0.35%
	Unknown or some implanted	972	3.07%	947	4.31%
	Implanted	12986	41.02%	6628	30.19%
Vaccination	Not vaccinated	2522	7.97%	1734	7.90%
	VAC 24	1612	5.09%	1091	4.97%
	VAC 34	10233	32.33%	6435	29.31%
	VAC 34+	795	2.51%	465	2.12%
	VAC 45	4909	15.51%	3319	15.12%
	VAC PreCon	805	2.54%	432	1.97%
	One respiratory vaccination	6943	21.93%	5584	25.43%
	Two or more respiratory vaccinations	3836	12.12%	2897	13.19%
Weaning	Weaned calves	11081	35.01%	8515	38.78%
	Weaning w/ respiratory vaccination	5367	16.95%	4764	21.70%
Pinkeye vaccinated	Vaccinated	233	0.74%	151	0.69%
***H. somni* vaccinated**	Vaccinated	1059	3.35%	663	3.02%
BVD PI-negative	Tested	176	0.56%	119	0.54%
Bangs vaccinated	Vaccinated			3398	15.48%
Age-and-source verified	Calves enrolled in program	2709	8.56%	1678	7.64%
Horns	Some, tipped and all horns	3396	10.73%	3026	13.78%
Breed	Cattle w/ ear	7701	24.33%	5992	27.29%
	English & English cross	3362	10.62%	1974	8.99%
	Continental & Continental cross	568	1.79%	423	1.93%
	English/Continental cross	12620	39.87%	9106	41.47%
	Black & black-white-faced	5304	16.76%	3275	14.92%
	Predominantly Angus	1715	5.42%	990	4.51%
	Predominantly Red Angus	385	1.22%	197	0.90%
Region of origin	West	6079	19.20%	4337	19.75%
	Rocky Mountain/North Central	14568	46.02%	9350	42.58%
	South Central	8538	26.97%	6300	28.69%
	Southeast	2470	7.80%	1970	8.97%

4.5 Model Specifications

The hedonic pricing model estimated in this study was based on the theoretical understanding and empirical characteristics presented in Chapters 3 and 4, respectively. Equation 13 provided the general framework for a feeder calf pricing model, and a price-dependent model specific to the available data is presented by Equation 14:

$$Price_{it} = f(Lot_{it}, Lot_{it}^2, Wt_{it}, Wt_{it}^2, WtVar_{it}, Frame_{it}, Flesh_{it}, Implant_{it}, Home_{it}, VAC_{it}, Pink_{it}, Hsomni_{it}, PIneg_{it}, Bangs_{it}, ASV_{it}, Horns_{it}, Breed_{it}, Diff_{it}, Region_{it}, FdrFtrs_{t}, CrnFtrs_{t}). \quad \textbf{(14)}$$

The price of an individual lot of cattle i on auction date t is dependent on the individual lot characteristics and auction day market forces where …

- Lot_{it} = number of head in the lot
- Wt_{it} = average per head weight (lbs.) of the lot
- $WtVar_{it}$ = weight variation within the lot (3 binary variables)
- $Frame_{it}$ = frame score of the lot (3 binary variables)
- $Flesh_{it}$ = flesh score of the lot (4 binary variables)
- $Implant_{it}$ = implant protocol and related management used on the lot (5 binary variables)
- $Home_{it}$ = home-raised status of the lot (1 binary variable)
- VAC_{it} = respiratory vaccination and weaning protocol used on the lot (8 binary variables)
- $Pink_{it}$ = pinkeye vaccination used on the lot (1 binary variable)
- $Hsomni_{it}$ = *H. somni* vaccination used on the lot (1 binary variable)
- $PIneg_{it}$= BVD PI-negative test used on the lot (1 binary variable)
- $Bangs_{it}$ = Bangs vaccination used on the lot (1 binary variable, heifers only)
- ASV_{it} = ASV protocol used on the lot (1 binary variable)
- $Horns_{it}$ = presence of horns in the lot (1 binary variable)
- $Breed_{it}$ = breed influence or hide color of the lot (7 binary variable)
- $Diff_{it}$ = days difference between the sale and delivery dates
- $Region_{it}$ = U.S. region of the lot (4 binary variables)
- $FdrFtrs_{t}$ = previous day's nearby feeder cattle futures contract price
- $CrnFtrs_{t}$ = previous day's deferred corn futures contract price

Lot size, weight and the futures contract prices are represented as quantitative variables in the analysis. The coefficient estimates resulting from these variables in the hedonic model will each reflect different interactions based on the measured effect of the dependent variable. The price effects of remaining characteristics are measured through binary variables, or dummy variables, that represent the qualitative management traits described previously in the chapter. The dummy variables assume a value of one whenever a lot, genetic, management or marketing characteristic presents itself in a given lot of cattle. Otherwise, the dummy variable remains zero. The coefficient estimates derived for each dummy variable represent the dollar per hundredweight shift in price that occurs when this characteristic is present in the lot. Collectively, these dummy variables identify the price effect of known value-added management on cattle sold through the SLA video market. A summary of the variables utilized for each model characteristic are provided in Table 4.8.

The empirical model was developed with the goal of balancing previously published research models with the new characteristics presented in the SLA video market database. The models structure and use of non-linear variables remains true to the foundational research of James and Farris (1971), Menzie et al. (1972), and Faminow and Gum (1986). The variables used to represent genetic influence, vaccination protocol and weaning strategies are adapted from work by King et al. (2006) and Blank et al. (2006 and 2009). Schroeder et al. (1988) provided the guidelines for applying futures market contract prices as proxy variables for market conditions. At the same time, the SLA database provided new opportunities to build a hedonic pricing model that better estimated the influence of vertical coordination on feeder calf prices. New traits for breed influence, vaccination protocols, weaning strategies, ASV, as well as natural and NHTC markets evolved over 14 years at a national marketplace. Lessons from previous feeder calf pricing research were applied to these new traits to estimate the effect of U.S. buyer preferences on feeder calf prices.

Table 4.8 - Description of Model Variables

Model Characteristic	Variable Description	Model Variable
Intercept	Intercept	INT
Lot size	Number of head	LOT
(Lot size)^2	Number of head squared	LOT^2
Weight	Average base weight of lot	WT
(Weight)^2	Average base weight of lot squared	WT^2
Frame	Small to medium	SM_FM
	Medium to medium-large mix	MML_FM
	Medium-large to large	MLM_FM
Flesh	Light to light-medium	LLM_FL
	Light-medium to medium mix	LMM_FL
	Medium	M_FL
	Medium to medium-heavy mix to heavy	MMHH_FL
Weight variation	Even to fairly even	EFE_WV
(uniformity)	Uneven	UE_WV
	Very uneven	VE_WV
Implant	Not implanted	NOIMP
	Natural eligible - Not implanted	NAT_NOIMP
	NHTC eligible - Not implanted	NHTC_NOIMP
	Unknown or some implanted	UKN_IMP
	Implanted	IMP
Vaccination	Not vaccinated	NOVAC
	VAC 24 Protocol	VAC24
	VAC 34 Protocol	VAC34
	VAC 34+ Protocol	VAC34P
	VAC 45 Protocol	VAC45
	VAC Precon Protocol	VACPC
	One respiratory vaccination	1VAC
	Two or more respiratory vaccinations	2VAC
	Weaning w/ respiratory vaccination	WEANVAC
Pinkeye vaccinated	Vaccinated	PINK
***H. somni* vaccinated**	Vaccinated at least once	HSOMNI
BVD PI-negative	Tested negative	PINEG
Bangs vaccinated	Vaccinated	BANGS
Age-and-source verified	Verified for age and source	ASV
Horns	Some, tipped or all horns	HORNS
Breed	Cattle w/ ear	EAR
	English & English cross	ENG
	Continental & Continental cross	ENG_CON
	English/Continental cross	CON
	Black & black-white-faced	BLK
	Predominantly Angus	BLK_ANG
	Predominantly Red Angus	RED_ANG
Long-run price variation	Feeder cattle futures price	FDRFTRS
Expected feed costs	Corn futures price	CRNFTRS
Region of origin	West	WEST
	Rocky Mountain/North Central	NC
	South Central	SC
	Southeast	SE
Days to delivery	Days between sale and delivery date	DAYSDIF

4.6 Procedures and Methods

The proposed research model was estimated with OLS regression techniques. Five multi-year hedonic pricing models were built from the proposed model, each representing a two- to four-year period where SLA lot descriptions included similar characteristics. Annual models were also estimated from 2004 to 2009 to better understand the influence of recent value-added management on calf prices. A total of 22 models were estimated in this study. The database was analyzed with SAS, version 9.2, analytical software, and the REG procedure was used to determine the coefficient estimates and test the statistical significance of results.

4.6.1 Multi-Year and Annual Empirical Model Organization

The database was analyzed using multi-year hedonic pricing models to estimate how price determinants have changed as production practices and markets evolved in the beef industry. Multi-year hedonic pricing models also increase the number of observations used in regression results. Table 4.1 provided a timeline for SLA lot description characteristics. Descriptions remained relatively unchanged through the late 1990s and early 2000s and allowed for longer run models during that time period. In 2004, SLA began to add more management and marketing characteristics in lot descriptions. Shorter run pricing models were developed to account for the new variables.

Annual models were developed from 2004 to 2009 to compliment the multi-year analysis and account for the influence of changing genetic, management and marketing characteristics on calves sold through SLA. The annual analysis provides a year-to-year snapshot of calf price determinant changes as buyers were informed of new traits. These results are more susceptible to variation compared to multi-year models due to a smaller number of observations. When evaluated as a whole, the annual estimates can illustrate how dynamic industry changes are affecting cow-calf producer revenue on a national level. A detailed list of model years and percent of usable observations used in each model are presented in Table 4.9.

Table 4.9 - Summary of SLA Video Market Feeder Calf Hedonic Pricing Models

Model Years	Years Analyzed	Steer Lots	Heifer Lots	% of Total Observations
1996 to 1999 *	4	6597	4564	20.82%
2000 to 2003	4	9334	7020	30.50%
2004 to 2005	2	6427	4552	20.48%
2006 to 2007	2	4459	2787	13.52%
2008 to 2009	2	4802	3019	14.59%
SUBTOTAL	**14**	**31619**	**21942**	**99.90%**
2004	1	2998	2179	9.66%
2005	1	3429	2373	10.82%
2006	1	2097	1283	6.30%
2007	1	2362	1504	7.21%
2008	1	2387	1505	7.26%
2009	1	2415	1514	7.33%
SUBTOTAL	**6**	**15688**	**10358**	**48.58%**

The number of VAC Precon observations were insufficient for analyzing price effects and were removed from the model.

4.6.2 White Test for Heteroskedasticity

One of the assumptions made with OLS regression techniques is that regression estimate errors have a constant variance. This is considered homoskedasticity. However, with cross-sectional and time-series data, estimates can have a non-constant variance, known as heteroskedasticity. The estimates determined through OLS are unbiased but inefficient under the presence of a non-constant variance. This means the estimation results have biased standard errors, and when heteroskedasticity is present and unaccounted for the P-values calculated from those errors are also inaccurate.

Residual errors in the model can be tested for heteroskedasticity using the White Test. The test involves regressing the squared residuals on all dependent variables, their squares and their cross-products. The White Test is useful in detecting robust standard errors since it is often difficult, if not impossible, to determine the source of heteroskedasticity. White (1980) also provided an estimation technique to calculate unbiased standard errors when heteroskedasticity exists. The new errors are called heteroskedasticity-consistent standard errors, or White standard errors (Maddala and Lahiri 2009, p.211-221). The REG procedure in SAS has options for performing White's model specification test and estimating White standard errors. The SPEC option tests for the presence of heteroskedasticity. The OLS estimated standard errors can be used when test results are significant at less than a 95 percent confidence level. When the test's confidence level is 95 percent or more, White standard errors should be calculated using the ACOV option (SAS Institute Inc. 2008, p. 5569-5570). The White Test will be performed on each model and the test results will be shared with each analysis. Models with heteroskedasticity will be estimated with White standard errors, and those errors will be used in calculating the P-values for the regression results.

4.6.3 Collinearity Test

The standard errors for coefficient estimates become less precise when regression estimates are nearly linear combinations of other estimates in the model. This condition is referred to as collinearity or multi-collinearity. Belsey, Kuh and Welsch (1980) discussed the computational and statistical problems associated with collinearity. The problem arises in ill conditioned databases where additional information does not contribute new and independent data for regression modeling. The researchers provided a diagnostic procedure for identifying degrading collinearity and estimating its influence on regression estimates. The economists suggest an approach that estimates the proportion of variation in each model variable using an $X'X$ data matrix. The proportion of variation calculations include an eigenvalue extracted from the data and a condition index calculated using the square root of the ratio of the largest eigenvalue to each individual eigenvalue in the series. Variation proportion is calculated for each condition index with the largest condition index being the condition number of the scaled X matrix (SAS Institute Inc., p. 5549).

Researchers can use the diagnostic tool to determine the variation proportion for each variable in the model to determine if, and to what degree, collinearity degradation exists in the model. The diagnostic tool recommended by Belsey, Kuh and Welsh can be estimated in SAS using the COLLIN option in the REG procedure (SAS Institute Inc., p. 5549). Collinearity exists when a condition index more than 30 exists and two or more variables have a variance proportion of more than 0.5 (Belsey, Kuh and Welsh, p. 112). The collinearity diagnostic procedure described will be used in the analysis of each model. If degrading collinearity is present in any of the estimated model coefficients, it will be reported in the regression results.

4.6.4 Testing for Differences among Coefficient Estimates

Ordinary Least Squares regression analysis can be used to determine if estimates are statistically different from zero. However, a weakness of OLS regression analysis is the inability to determine statistical differences among parameter estimates. A joint-hypothesis test can overcome this fault by comparing the difference in fit for two or more parameter estimates in an OLS model. An F-test is commonly used in economic analyses for joint-hypothesis test due to its broad application. Similar to other hypothesis tests, the F-test compares the argument for a null hypothesis H_0 to an alternative hypothesis H_1. An F-statistic is calculated for the null hypothesis and is compared to an existing distribution's F-statistic based on the test's degrees of freedom and desired confidence interval (Allen 1997, p. 106-112). The F-test is particularly useful in this study for determining statistical differences between dummy variables for breed and vaccination protocol and the efficiency of SLA markets in reflecting national feeder cattle prices.

The first argument the study will test is the difference between Angus and black and black-white faced calves. The F-test will determine whether the Angus breed price effect is statistically different from other black-hided calves in the SLA video market. The Angus breed has become one of the most recognized beef breeds through the success of the Certified Angus Beef® brand. The brand was established in 1979, and 10 years later packers were paying premiums for Angus cattle meeting the brand's specifications. The live-animal requirements for the brand require cattle to be more than 51 percent black hided (Certified Angus Beef LLC 2006). The additional premiums generated by Certified Angus Beef® qualifying cattle have led to black-hided cattle in other beef breeds.

The model's dummy variables account for SLA sale lots that are 90 percent or more Angus and similarly black and black-white faced. When all other traits of a sale lot are equal, the only difference between these two populations is the breed or color provided in the lot description. An F-test was developed to determine statistical differences among all breed dummy variables as well as the statistical difference between Angus and black and black-white faced cattle. The null hypotheses for these tests are available in Equations 15 and 16 where β represents the coefficient estimates for the designated dummy variable:

$$H_0: \beta_{EAR} = \beta_{ENG} = \beta_{ENG\_CON} = \beta_{CON} = \beta_{BLK} = \beta_{BLK\_ANG} = \beta_{BLK\_ANG} = \beta_{RED\_ANG} \quad \textbf{(15)}$$

$$H_0: \beta_{BLK} = \beta_{BLK\_ANG}. \quad \textbf{(16)}$$

These equations will be compared to the alternative hypothesis that any one relationship among breed is not equal. Equation 15 tests for statistically significant differences among all breed claims, while Equation 16 focuses on the Angus and black and black-white faced cattle. When the null hypothesis is rejected at the 95 percent confidence level, a statistical difference among breed claims exists.

Preconditioning and certified health programs began as a way to differentiate cattle with known vaccination and weaning history. Bulut and Lawrence (2006) noted that feeder cattle auction markets were generally not efficient in exchanging health-related information from sellers to buyers. They recognized third-party health certification as a possible solution to asymmetric information problems with preconditioned calf sales. The economists admitted the solution was imperfect. Certified health programs that fail to convey integrity and trust to buyers will not efficiently transfer health information in calf auction markets. The video market database does not explicitly measure program integrity or buyer trust in SLA certified health protocol. However, an F-test can be used to compare differences among the VAC protocol and their similar non-certified counterparts in SLA video market sales. A statistical difference between certified health programs and general vaccination and weaning claims will illustrate significant variation in buyer preferences. The results will provide a general understanding for the efficiency of VAC protocols at SLA video market sales. The null hypotheses for each F-test are presented in Equations 17 to 21. Equation 17 tests the statistical difference among all vaccination programs, while Equations 18 to 21 test differences among VAC protocol and a similar combination of general vaccination and weaning claims:

$$H_0: \beta_{VAC24} = \beta_{VAC34} = \beta_{VAC34P} = \beta_{VAC45} = \beta_{VACPC} = \beta_{1VAC} = \beta_{2VAC} \quad \textbf{(17)}$$

$$H_0: \beta_{VAC24} = \beta_{1VAC} \quad \textbf{(18)}$$

$$H_0: \beta_{VAC34} = \beta_{1VAC} \quad \textbf{(19)}$$

$$H_0: \beta_{VAC34P} = \beta_{2VAC} \quad \textbf{(20)}$$

$$H_0: \beta_{2VAC} + \beta_{WEANVAC} = \beta_{VAC45}. \quad \textbf{(21)}$$

Each null hypothesis is tested against the H_1 alternative hypothesis that claims any one relationship among vaccination is not equal. A rejection of the null hypotheses denotes statistical differences among the tested vaccination programs.

The coefficient estimate associated with the feeder cattle futures contract price represents the video market's efficiency in reflecting U.S. feeder cattle market conditions in the prices of calves. A parameter estimate equal to one would indicate perfect efficiency as compared to the futures contract market. Theoretical expectations would predict a coefficient estimate close to one for steers that fit the Chicago Mercantile Exchange contract specification for the feeder cattle futures contract, which is a medium-large frame steer weighing 650 to 849 lbs (CME 2010). However, short run models and video auction markets that result in the sale of cattle weights that are different from the futures contract weight range can often result in estimates less than one. The OLS regression results will determine if the $FdrFtrs$ parameter estimate is statistically significant, while the F-test represented by the null hypothesis below will denote if the result is statistically different than one.

$$H_0\colon \beta_{FDRFTRS} = 1. \tag{22}$$

The alternative hypothesis for Equation 22 is that the estimate is not equal to one.

CHAPTER 5 - Results

The empirical results of the described feeder calf hedonic pricing model using the previously detailed SLA video market data are summarized in this chapter. The results discussion will focus on the multi-year model developed from 2008 to 2009 data and the six annual models developed from 2004 to 2009 data. A more narrowly focused discussion will allow for a thorough analysis of the more recent model estimates and the influence of relevant industry trends on SLA video market calf prices. Estimates from the 2008 to 2009 multi-year model will be compared to existing research in feeder calf price analysis and detailed explanations will be provided with the results. The 2004 to 2009 annual model estimates later in the chapter will focus on the six-year trends in SLA video market price determinants and program participation. Summary tables in Appendix A provide the averages and coefficient estimates of the 1996 to 2007 multi-year models.

5.1 Results of the 2008 to 2009 SLA Hedonic Pricing Model

The 2008 to 2009 SLA dataset provides a snapshot of the most relevant genetic, management and marketing characteristics available to cow-calf producers. The 40-variable model was estimated using 4,802 steer lots and 3,019 heifer lots sold on SLA video auction market from June 2008 through September 2009. Table 5.1 summarizes the average price, lot size, weight, sale and delivery information for sale lots used in the analysis.

Table 5.1 - Average Price, Lot, Weight, Sale and Delivery Data, 2008 to 2009

Mean variable	Steers - 450 to 750 lbs.				Heifers - 400 to 700 lbs.			
	Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum
Sale price ($ per cwt.)	$110.33	9.41	$80.50	$144.50	$102.78	8.61	$77.00	$145.00
Nearby feeder cattle futures contract ($ per cwt.)	$107.44	6.38	$96.55	$117.30	$107.43	6.39	$96.55	$117.30
Lot size (# of head)	124.60	78.66	25.00	1165.00	116.14	71.30	20.00	1000.00
Base weight (lbs.)	583.08	69.06	450.00	750.00	544.43	65.25	400.00	700.00
Sale month (# of month)	7.44	0.84	6	9	7.44	0.86	6	9
Delivery month (# of month)	9.99	1.37	1	12	9.98	1.47	1	12
Days to delivery (days between sale and delivery)	77.67	36.79	0	180	78.10	37.16	1	180

Steers sold for an average price of $110.33 per cwt. with an average base weight of 583 lbs. On average, heifers weighed 544 lbs and sold for around $7.50 per cwt. less than steers. Nearly 70 percent of steers and heifers in the analysis sold at an average base weight between 500 and 649 lbs (Figure 5.1 and Figure 5.2). Sartwelle et al. (1996a) and Schroeder et al. used a 300 to 599 lbs. range for lightweight calves, and Bailey et al. (1993) used a simple weight break at 600 lbs. The analysis used a weight range similar to Schroeder et al. (1988), but it was necessary to shift the range to accommodate for the distribution of average base weights. Mean sale and delivery months were nearly identical for the two groups of cattle, and the average calf delivery date was two and a half months after the sale.

The variables analyzed in each model are summarized in Table 5.2. A variable needed to be represented by at least two percent of total observations in one gender to be included in the hedonic pricing model. Variables for continuous traits such as extremely small or large frame size and flesh were grouped to represent at least two percent of all observations. Variables that approached the minimum threshold represented lots with NHTC- eligible, non-respiratory vaccinated, VAC Precon, Red Angus influenced and Continental-influenced calves.

The parameter estimates of the hedonic pricing model are in Table 5.3. Overall, the estimates are consistent with previous research, and the results are consistent with expectations. In general, more intensive value-added management received a premium at SLA video auction markets. Adjusted R^2 values were evaluated as an indication for goodness of fit since each model included a large number of observations. The steer model accounted for approximately 78 percent of the variation found in SLA video market steer prices, while the estimated model for heifers explained around 73 percent of price variation. White test results determined that heteroskedasticity was a significant factor in the results, and White standard errors were used to calculate the P-values for each coefficient. Also, the regression results were not susceptible to bias from degrading collinearity.

Figure 5.1 - Weight Distribution in Steers, 2008 to 2009

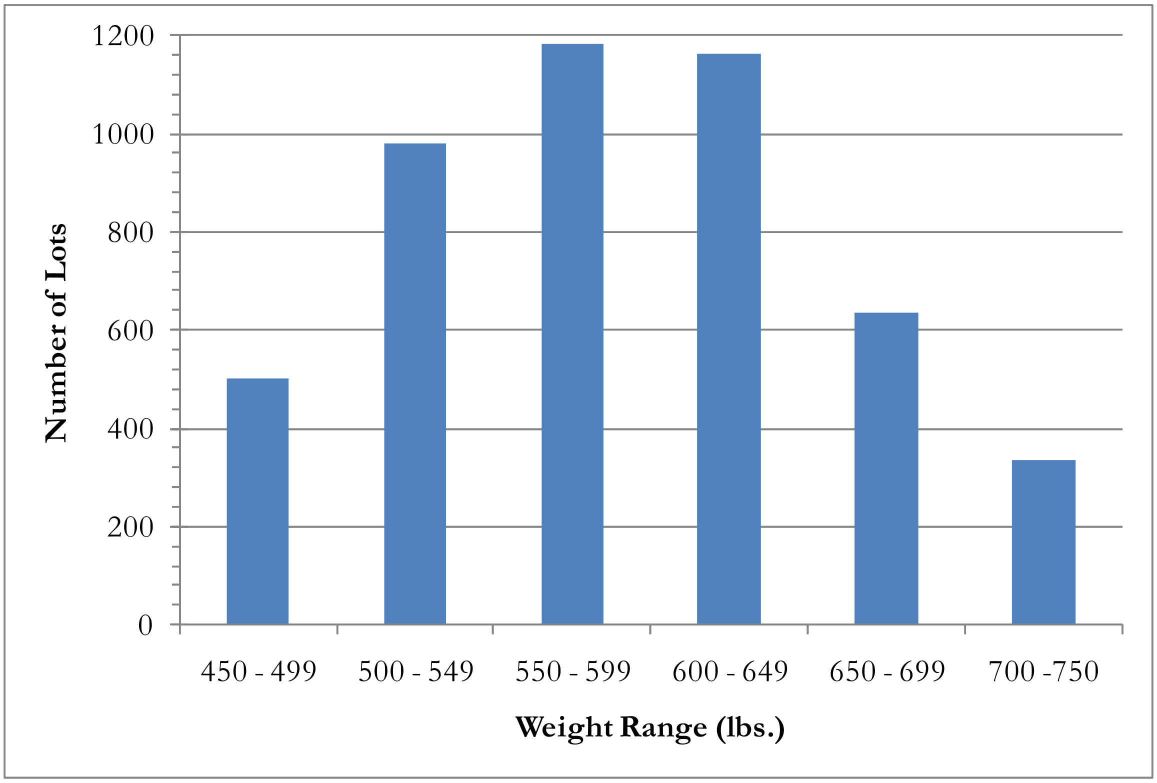


Figure 5.2 - Weight Distribution in Heifers, 2008 to 2009

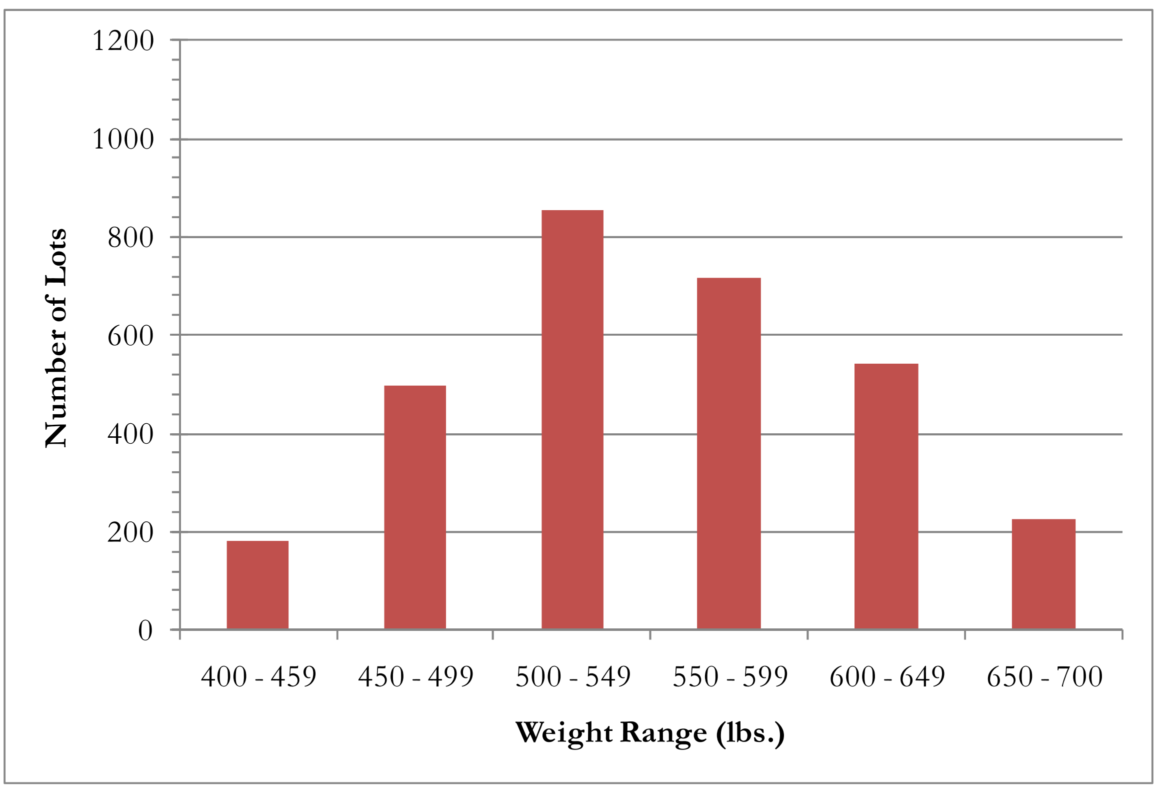


Table 5.2 - Means for Hedonic Pricing Model, 2008 to 2009

Characteristic	Variable description	Steers - 450 to 750 lbs. Observations		Heifers - 400 to 700 lbs. Observations	
		(# of lots)	(% of lots)	(# of lots)	(% of lots)
Frame	Small to medium	2097	43.67%	1352	44.78%
	Medium to medium-large Mix	2122	44.19%	1290	42.73%
	Medium-large to large	583	12.14%	377	12.49%
Flesh	Light to light-medium	222	4.62%	138	4.57%
	Light-medium to medium mix	327	6.81%	239	7.92%
	Medium	4125	85.90%	2566	85.00%
	Medium to medium-heavy mix to heavy	128	2.67%	76	2.52%
Weight variation	Even to fairly even	329	6.85%	174	5.76%
(uniformity)	Uneven	4292	89.38%	2717	90.00%
	Very uneven	181	3.77%	128	4.24%
Implant	Not implanted	1745	36.34%	1247	41.31%
	Natural eligible - Not implanted	1532	31.90%	1032	34.18%
	NHTC eligible - Not implanted	82	1.71%	77	2.55%
	Unknown or some implanted	177	3.69%	143	4.74%
	Implanted	1316	27.41%	567	18.78%
Vaccination	Not vaccinated	97	2.02%	58	1.92%
	VAC 24	470	9.79%	327	10.83%
	VAC 34	1631	33.97%	1009	33.42%
	VAC 34+	795	16.56%	465	15.40%
	VAC 45	1062	22.12%	690	22.86%
	VAC Precon	108	2.25%	32	1.06%
	One respiratory vaccination	269	5.60%	187	6.19%
	Two or more respiratory vaccinations	370	7.71%	251	8.31%
Weaning	Weaned calves	1551	32.30%	1012	33.52%
	Weaning w/ respiratory vaccination	381	7.93%	290	9.61%
Pinkeye vaccinated	Vaccinated	233	4.85%	151	5.00%
***H. somni* vaccinated**	Vaccinated	1059	22.05%	663	21.96%
BVD PI-negative	Tested	176	3.67%	119	3.94%
Bangs vaccinated	Vaccinated			557	18.45%
Age-and-source verified	Calves enrolled in program	1810	37.69%	1125	37.26%
Horns	Some, tipped and all horns	255	5.31%	184	6.09%
Breed	Cattle w/ ear	761	15.85%	500	16.56%
	English & English cross	388	8.08%	230	7.62%
	Continental & Continental cross	101	2.10%	89	2.95%
	English/Continental cross	1609	33.51%	1075	35.61%
	Black & black-white-faced	1505	31.34%	898	29.74%
	Predominantly Angus	320	6.66%	170	5.63%
	Predominantly Red Angus	118	2.46%	57	1.89%
Region of origin	West	1199	24.97%	820	27.16%
	Rocky Mountain/North Central	2319	48.29%	1372	45.45%
	South Central	974	20.28%	635	21.03%
	Southeast	310	6.46%	192	6.36%

Table 5.3 - Coefficients Estimates for Hedonic Pricing Model, 2008 to 2009

		Steers - 450 to 750 lbs.			Heifers - 400 to 700 lbs.		
Characteristic	**Variable Description**	Observ. (lots)	Coefficient Estimates	P-Value (P>|t|)	Observ. (lots)	Coefficient Estimates	P-Value (P>|t|)
Intercept	Intercept	4802	148.5133	< 0.0001	3019	112.3773	< 0.0001
Lot size	Number of head	4802	0.0127	< 0.0001	3019	0.0115	0.0016
(Lot size)^2	Number of head squared	4802	-0.00001	0.0012	3019	-0.00001	0.1379
Weight	Average base weight of lot	4802	-0.3825	< 0.0001	3019	-0.3130	< 0.0001
(Weight)^2	Average base weight of lot squared	4802	0.00027	< 0.0001	3019	0.00024	< 0.0001
Frame	Small to medium	2097	-0.3768	0.0087	1352	-0.0250	0.891
	Medium to medium-large mix	2122	Base		1290	Base	
	Medium-large to large	583	-0.2109	0.2766	377	-0.0705	0.7709
Flesh	Light to light-medium	222	0.4971	0.0864	138	0.6584	0.0813
	Light-medium to medium mix	327	0.7022	0.0152	239	-0.0402	0.9142
	Medium	4125	Base		2566	Base	
	Medium to medium-heavy mix to heavy	128	0.0146	0.9734	76	0.1517	0.7753
Weight variation	Even to fairly even	329	0.5293	0.0282	174	1.3520	0.0006
(uniformity)	Uneven	4292	Base		2717	Base	
	Very uneven	181	-0.0280	0.9468	128	0.5150	0.3174
Implant	Not implanted	1745	Base		1247	Base	
	Natural eligible - Not implanted	1532	0.2614	0.0885	1032	0.5429	0.0045
	NHTC eligible - Not implanted	82	1.5056	0.0047	77	1.5077	0.0061
	Unknown or some implanted	177	-1.2818	0.0003	143	-0.8558	0.0278
	Implanted	1316	0.2100	0.1988	567	0.3406	0.12
Vaccination	Not vaccinated	97	Base		58	Base	
	VAC 24	470	1.6984	0.0054	327	1.2805	0.121
	VAC 34	1631	3.6022	< 0.0001	1009	2.4251	0.002
	VAC 34+	795	3.5937	< 0.0001	465	2.7136	0.0006
	VAC 45	1062	7.6119	< 0.0001	690	6.6067	< 0.0001
	VAC Precon	108	8.9857	< 0.0001	32	4.7158	< 0.0001
	One respiratory vaccination	269	1.3227	0.048	187	0.5589	0.5409
	Two or more respiratory vaccinations	370	2.1795	0.003	251	1.8258	0.059
	Weaning w/ respiratory vaccination	381	4.9487	< 0.0001	290	4.4151	< 0.0001
Pinkeye vaccinated	Not vaccinated or unknown	4569	Base		2868	Base	
	Vaccinated	233	1.1993	0.0001	151	1.0753	0.0066
***H. somni* vaccinated**	Not vaccinated or unknown	3743	Base		2356	Base	
	Vaccinated at least once	1059	0.3845	0.0121	663	0.1795	0.3885
BVD PI-negative	No	4626	Base		2900	Base	
	Yes	176	-0.0712	0.8476	119	0.2241	0.6424
Bangs vaccinated	Not vaccinated or unknown				2462	Base	
	Vaccinated				557	-0.5294	0.0463
Age-and-source verified	No	2992	Base		1894	Base	
	Yes	1810	1.5812	< 0.0001	1125	1.6613	< 0.0001
Horns	No horns	4547	Base		2835	Base	
	Some, tipped and all horns	255	-0.8169	0.0369	184	-0.8141	0.0468
Breed	Cattle w/ ear	761	Base		500	Base	
	English & English cross	388	3.4971	< 0.0001	230	3.3629	< 0.0001
	Continental & Continental cross	101	4.0537	< 0.0001	89	2.7863	< 0.0001
	English/Continental cross	1609	4.0870	< 0.0001	1075	3.8702	< 0.0001
	Black & black-white-faced	1505	5.8125	< 0.0001	898	5.4301	< 0.0001
	Predominantly Angus	320	6.5510	< 0.0001	170	6.0400	< 0.0001
	Predominantly Red Angus	118	6.5575	< 0.0001	57	13.0801	< 0.0001
Price variation	Feeder cattle futures price	4802	0.7943	< 0.0001	3019	0.7647	< 0.0001
Region of origin	West	1199	-3.9464	< 0.0001	820	-3.1566	< 0.0001
	Rocky Mountain/North Central	2319	0.8905	0.0003	1372	0.9034	0.009
	South Central	974	Base		635	Base	
	Southeast	310	-8.5114	< 0.0001	192	-8.0434	< 0.0001
Days to delivery	Days between sale and delivery date	4802	-0.0222	< 0.0001	3019	-0.0290	< 0.0001
Analysis of Variance and Homoskedasticity		***Adj. R^2 Value:*** *0.7829* ***Root MSE:*** *4.38321*			***Adj. R^2 Value:*** *0.7280* ***Root MSE:*** *4.49139*		
		White Test Results: *P>Chi^2 <0.0001* *DF = 713, Chi-Square = 959.25*			***White Test Results:*** *P>Chi^2 =0.0002* *DF = 742, Chi-Square = 857.71*		

5.1.1 Price Effect of Lot Characteristics

The only lot characteristic evaluated in the study was the effect of region on calf price. The coefficient estimates represent the regional price difference in dollars per hundredweight compared to identical calves from the South Central region. Each region showed a price difference that was statistically significant at the 95 percent confidence level or higher, and the estimates were similar across genders. Cow-calf producers in the Rocky Mountain and North Central regions can expect an additional $0.90 per cwt. for steers and heifers. Steers in the West will receive a $3.95 per cwt. discount and heifers will be marked down $3.16 per cwt. Producers in the Southeast receive the largest discounts with $8.51 and $8.05 per cwt. price differences for steers and heifers, respectively, compared to similar South Central calves.

The regions were parallel to those by King et al. (2006) and the results were similar. Western calves were discounted around $2.42 per cwt. to the South Central region, while calves in the North Central region received a $1.60 per cwt. premium. The discount for Southeast calves was less extreme with a $4.20 per cwt. discount. However, Bailey et al. (1993) found larger discounts for Southeast calves. Lightweight steers and heifers from the Southeast received discounts of $8.09 and $7.02 per cwt. compared to calves from Colorado, Kansas, Nebraska, Missouri, Iowa and Illinois in that study. The discounts applied to West coast calves were also similar to this analysis. Steers were discounted $5.06 per cwt., and heifers received $4.56 per cwt. less. Blank et al. (2006 and 2009) compared the prices of calves originating in the West to North Central calves. The discount for Western calves in that study was considerably higher than previous research ranging from $8.77 to $11.63 per cwt. Comparable discounts in this study would be around $5 per cwt. for steers and $4 per cwt. for heifers.

5.1.2 Price Effect of Genetic Characteristics

Breed influence, presence of horns and frame score represent the genetic characteristics that were evaluated in the hedonic pricing model. In general, the frame score in the written lot description had the least influence on sale price. Steer lots described as having medium or smaller frames received a $0.38 per cwt. discount compared to lots of medium to medium-large mixed steers. This estimate was the only significant price determinant for frame size in either model. These results are different from the SLA video market research by Bailey et al. (1993 and 1995). The 1995 study found that large-framed feeder cattle brought $0.64 per cwt. more than small-framed cattle, and steer and heifer calves described as large and medium-large framed brought premiums ranging from $3.42 to $5.28 per cwt. in 1993. Turner et al. (1993) also found that excessively large and small cattle received discounts in Georgia Farm Bureau teleauction markets. Small-framed cattle received the highest discount at $6.65 per cwt. compared to medium-framed cattle, while medium-large cattle received a discount of $0.82 per cwt. These results are consistent with feeder calf pricing studies at local auction markets. Compared to medium-framed sale lots, Schultz et al. (2010) found a discount of $5.98 per cwt for small-framed calves and $0.75 per cwt. markdown for large cattle. These results were significant at the 90 percent confidence level, but decreases were also progressively more severe as frame size decreased in Schroeder et al. (1988). Small-framed cattle received the largest frame-based discounts in the research with discounts ranging from $4.11 to $9.81 per cwt.

There are two possible explanations for the different results in this analysis. The lot descriptions are developed by SLA representatives with the help of cow-calf producers. Sellers with small-framed calves would benefit from upward-biased grading procedures. In time, video market buyers would recognize this bias in the lot description and the price signals for frame size would become muted. It is likely that buyers also trust their own evaluation of frame size more than the scores listed in SLA lot descriptions. Experienced buyers could use details provided by the video and description of other characteristics to make their own assumptions on frame size and bid accordingly. Testing these explanations goes beyond the scope of this study, but presents an opportunity for further research.

The presence of horns resulted in discounts of around $0.80 per cwt. for steers and heifers. Considering the estimate includes the effect of mixed- and tipped-horn lots, the estimates are within the range of results found in other studies. Schroeder et al. (1988) found that horns led to discounts of $0.42 and $0.84 per cwt. in lightweight steers and heifers, respectively, while mixed horns did not elicit a statistically significant price difference. Dehorned and mixed-horn lots brought premiums of $0.63 and $0.40 per cwt., respectively, compared to horned lots in Lambert et al. (1989). Superior Livestock Auction estimates from Bailey et al. (1993) showed horned lightweight steers received discounts of $2.30 per cwt., and lightweight heifers received $1.82 less than polled calves. Lightweight steers with some horns received a statistically significant discount of $1.40 per cwt., while the prices for lightweight heifers with some horns remained unchanged.

Breed influence had the most noteworthy effect on calf prices compared to other genetic characteristics. The six variables analyzed in the steer and heifer models were each statistically significant at a confidence level more than 99 percent. The coefficient estimates can be interpreted as the dollar per hundredweight difference in price for calves compared to similar Brahman-influenced sale lots, designated in this model as "Cattle with ear." Breed had a similar effect on sale price across gender with Brahman-influenced calves receiving the lowest prices and Red Angus cattle receiving the highest. An F-test detects price differences among the breed influences represented in the study (Table 5.4). The test description is provided as well as a reference number to the null hypothesis equations detailed in Chapter 4. Overall, the breed effects were considered statistically different from one another. However, the price effect differences between Angus and black- and black-white faced calves were only considered statistically different for steers. In other words, Angus and black and black-white faced heifers can be considered statistically as having the same price effect in this analysis.

Table 5.4 - Multi-Year Model Breed Influence F-test Results, 2008 to 2009

F-test description	Null Hypothesis	Steers		Heifers	
		P-value	Test result	P-value	Test result
All breeds are equal	(15)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
Angus = black-hide color	(16)	0.0027	Reject H_0	0.1382	Fail to reject H_0

Red Angus calves received the highest premiums with a $6.56 and $13.08 per cwt. premium for steers and heifers, respectively. It should be noted that the sample size for Red Angus influenced calves was small for both steers and heifers. The three highest sale prices for Red Angus heifer lots were $134, $134 and $145 per cwt. These lots represented three of the top 10 sale prices for heifers recorded from 2008 to 2009 and were more than $30 per cwt. higher than the average heifer price. These prices combined with the low number of Red Angus observations were causing the higher price differential. Angus and black and black-white faced calves received the next highest premiums. Steers received premiums of $6.56 and $5.81 per cwt., respectively, while the $6.04 and $5.43 per cwt. premiums for Angus and black and black-white faced heifers should be considered the same based on F-test results. Premiums for English, Continental and English-Continental cross calves ranged between $3.50 and $4.09 per cwt. for steers and $2.79 and $3.87 per cwt. for heifers. The relative price effect of breed influence changed across genders; however, it should be noted that Continental-influenced calves were represented by two to three percent of the gender datasets. More variation for these coefficients can be expected based on the small number of observations.

Studies from the 1960s to 1970s generally showed that buyers preferred English-influenced calves compared to Brahman- and Continental-influenced calves (Williamson et al. 1961 and James and Farris 1971). Schwab (1975) published one of the first studies where Charolais calves received premiums over English breeds, and Kuehn (1979) found similar results in West Virginia auction markets. Continental-influenced calves became more widely known for performance and meat yield during the 1980s, and buyer familiarity with these characteristics led to dominant breed premiums in auction market studies through the 1980s (Schroeder et al. 1988). Buyer preferences for breed transitioned throughout the 1990s, and Angus-influenced and black-hided calves began to receive notable market premiums over other breeds during the 2000s. Smith et al. (2000) found black-hided and other Continental calves received a premium compared to Angus. These calves brought $2.66 and $1.17 per cwt. more, respectively. Avent et al. (2004) found Brahman-influenced calves were discounted $4.74 per cwt. compared to Angus calves, while black-hided and other Continental calves did not show a significant price difference to Angus-based calves. Schultz et al. (2010) found Angus calves received the highest market premiums, bringing $6.35 per cwt. more than Brahman-influenced calves. Angus-Hereford crosses received $5.98 per cwt. price premium, and Continental-cross calves received $2.54 per cwt. more than Brahmans. Other English-cross calves received a premium of $1.42 per cwt.

The relative importance among breed traits in this study is similar to research from the past 10 years. However, the price effect for breed influence is more pronounced than previous work. The relatively high estimates for breed-related traits in this study could support the explanations made for the lack of variation among frame-score variables. Advances in production science, and in particular breeding technology, may make breed influence a stronger indicator of future growth and performance in the stocker, backgrounding and feedlot sectors than frame size. If this is the case, it could be argued that buyers are more motivated to establish feeder calf price based on breed than frame score.

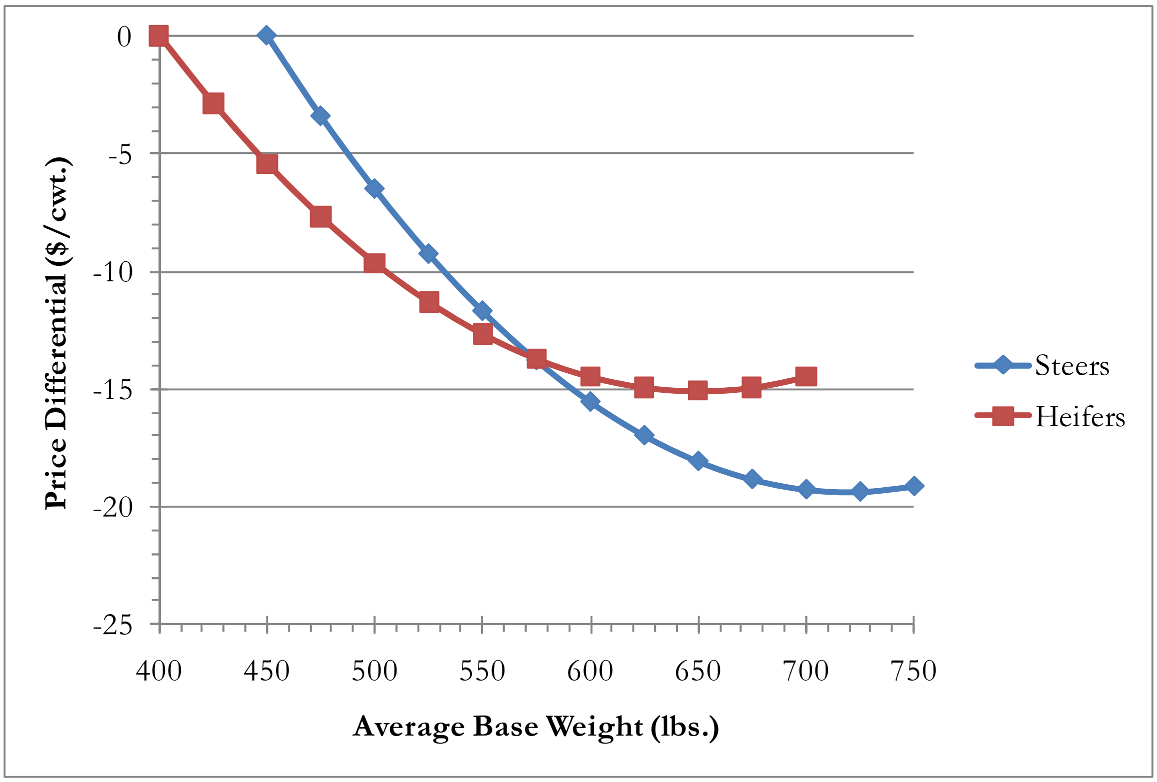
5.1.3 Price Effect of Management Characteristics

The influence of weight, weight variation, flesh score, implant protocol and vaccinations represent the management characteristics in the hedonic pricing model. Previous studies have examined the effect of weight, weight variation and flesh score, while relatively few studies have examined the implant and vaccination protocols influence on calf prices. The adoption of more intensive management at the cow-calf level allows for the analysis of these traits in detail through the SLA database.

The effect of weight and weight variation has been well documented in feeder calf pricing research. James and Farris were among the first agricultural economists to explore a non-linear price-weight relationship. Studies by Menzie et al. (1972), Kuehn (1979), and Faminow and Gum (1986) continued this modeling approach. Studies by Schroeder et al. (1988) and Bailey et al. (1991)

found non-uniform lots to be discounted anywhere from $0.11 to $0.58 per cwt., while Sartwelle et al. (1996a) found uniformity did not have a statistically significant effect on calf price. The 2008 to 2009 SLA video market estimates were similar to the previous research. A statistically significant non-linear price-weight relationship existed for both steers and heifers and is illustrated in Figure 5.3. The shape of the curves is consistent with previous research by Schultz et al. (2010), King et al. (2006) and Avent et al. (2004). Heifer sale lots with an average base weight of 652 lbs. received the largest discounts for weight at $15.35 per cwt. The largest weight discount for steers was $17.14 per cwt. at 708 lbs.

Figure 5.3 - Price-Weight Relationship for Steers and Heifers, 2008 to 2009



Premiums existed in SLA video markets for uniform sale lots. Steers with even to fairly even weight variation received an additional $0.53 per cwt., and uniform lots of heifers received premiums of $1.35 per cwt. Lots designated as very uneven were not discounted relative to uneven groups of calves. The premium was consistent with the $1.34 per cwt. premium for even to fairly even calves in King et al. (2006). However, Schroeder et al. (1988) and Bailey et al. (1991) estimated much smaller premiums ranging from $0.10 to $0.58 per cwt. for uniform calves. There is a possible explanation for the variation in estimates across studies. Video market buyers are accustomed to purchasing sale lots to fill large feedlot pens, and uniformity becomes increasingly more important to feedlot management and marketing as the number of cattle in a pen increases. Variability within a large pen of feedlot cattle increases inefficiency and makes per head feeding costs higher. It is possible that buyers have become more focused on uniformity with the use of individual calf management records and are bidding appropriately for its efficiency gains.

Flesh score was measured through the use of four dummy variables based on SLA descriptions for condition. The parameter estimates can be considered as the per hundredweight price difference of a given flesh score compared medium flesh calf lots. The models showed only one statistically significant price differential for flesh score across genders. Steer lots with light-medium to medium mixed flesh scores received a $0.70 per cwt. premium. Previous research has been mixed on the effect of flesh or conditions on feeder calf prices. Folwell and Rehburg (1976) concluded that fleshy stocker cattle in Washington received no notable price difference in the market, while later research from Lambert et al. (1989), Schroeder et al. (1988) and Sartwelle et al. (1996a) found statistically significant price differences based on flesh score.

Bailey et al. (1991) estimated the effect of flesh score on lightweight calf prices sold through the SLA video market and found similar results to this analysis. Steer calves received significant discounts of $1.22 per cwt and $2.16 per cwt. for medium and medium-heavy flesh scores relative to light flesh, respectively. Lightweight heifers did not receive statistically significant discounts. Schroeder et al. (1988) possibly offered the best explanation for the mixed signals for flesh-related price differentials in the market place. The economists found discounts applied to fleshy and thin lightweight calves can differ considerably based on season. Lightweight steers and heifers with thin condition were discounted $6.61 and $2.94 per cwt., respectively, in the fall, but they were priced similar to calves with normal flesh condition in the spring. Fleshy calves were more likely to be discounted in the spring with markdowns of $2.05 and $0.97 per cwt. for steers and heifers, respectively. In the fall, lightweight calves were less likely to receive discounts.

The estimated premium for lightweight steers with light-medium to medium mixed flesh score does not follow the trend outlined by Schroeder et al. (1988), but is consistent with Bailey et al. (1993). It is important to keep in mind that SLA video market sales are typically forward contract sales. Calf delivery occurs in the highest concentration one to 120 days after SLA video market sales. It would seem difficult to estimate calf flesh condition in a forward contract sales environment. Also, the $0.70 per cwt. premium is relatively modest compared to the premiums available based on breed and vaccination protocol.

The use of implants did not have a statistically significant influence on calf sales prices. However, not listing the implant protocol or only implanting some of the cattle in the sale lot resulted in significant discounts for both steers and heifers of $1.28 and $0.86 per cwt., respectively, compared to non-implanted cattle. These results would be consistent with research by Blank et al. (2006 and 2009), which found implants did not have a statistically significant difference on calf prices. The discount applied to unknown or partially implanted sale lots can be seen as the market price for mismanaged cattle. Calf buyers penalize the sellers for limiting their ability to use a uniform implant strategy or market these calves in a non-implanted beef program. The market premiums available for cattle eligible for natural and NHTC markets will be discussed in the marketing characteristics section.

Weaning and respiratory vaccination protocols were represented in the model by eight variables. The estimates can be interpreted as the dollar per hundredweight price difference for the vaccination or weaning practice compared to non-vaccinated, non-weaned calves. In general, premiums for the SLA VAC protocols increased as program requirements increased, and the results were similar to a comparable analysis by King et al. (2006). VAC 24 protocol received the lowest statistically significant premiums for verified health claims with a $1.70 per cwt. premium for steers. The premium difference between VAC 34 and VAC 34+ were similar for both steers and heifers. The steer premium for these programs was around $3.60 per cwt., and heifers received a premium of $2.42 to $2.71 per cwt. depending on the protocol. The VAC 45 program received some of the highest market premiums for its combination of vaccination and weaning requirements. Steers and heifers received statistically significant premiums of $7.61 and $6.61 per cwt., respectively. The low number of observations for steers and heifers certified for VAC Precon protocol led to mixed results across genders. Steers in the VAC Precon program received the highest vaccination-related premiums at $8.99 per cwt. However, the heifer premium was around $2 per cwt less than the VAC 45 program at $4.72 per cwt.

Non-certified respiratory vaccination programs also added value to the sale prices of SLA steer and heifer calves. Non-weaned steers given one respiratory vaccination received a premium of $1.32 per cwt. When those steers received multiple respiratory vaccinations the premium increased to $2.18 per cwt. Non-weaned heifers with one respiratory vaccination received a $0.56 per cwt. premium, and the premium increased to $1.83 per cwt. when two or more respiratory vaccinations were administered. However, the estimate for multiple respiratory vaccinations in heifers was not statistically significant at P-values equal to or less than 0.05. Calves receiving non-certified respiratory vaccinations could receive an additional premium over non-vaccinated, non-weaned calves by being weaned. The weaning premium represented an additional $4.95 per cwt. for steers and $4.42 per cwt. for heifers that received some form of respiratory vaccination. Home-raised cattle were generally non-weaned, lightweight calves. Figure 4.9 shows the weaning strategy for home-raised calves compared to other lots of cattle, and more than 60 percent of calves were non-weaned and home-raised calves. When the home-raised variable was included in the model it masked the effect of weaning. It was excluded in the model for this reason. The total value of the different weaning and respiratory vaccination protocol combinations are available in Figure 5.4 and Figure 5.5.

Figure 5.4 - Steer Vaccination and Weaning Program Value, 2008 to 2009

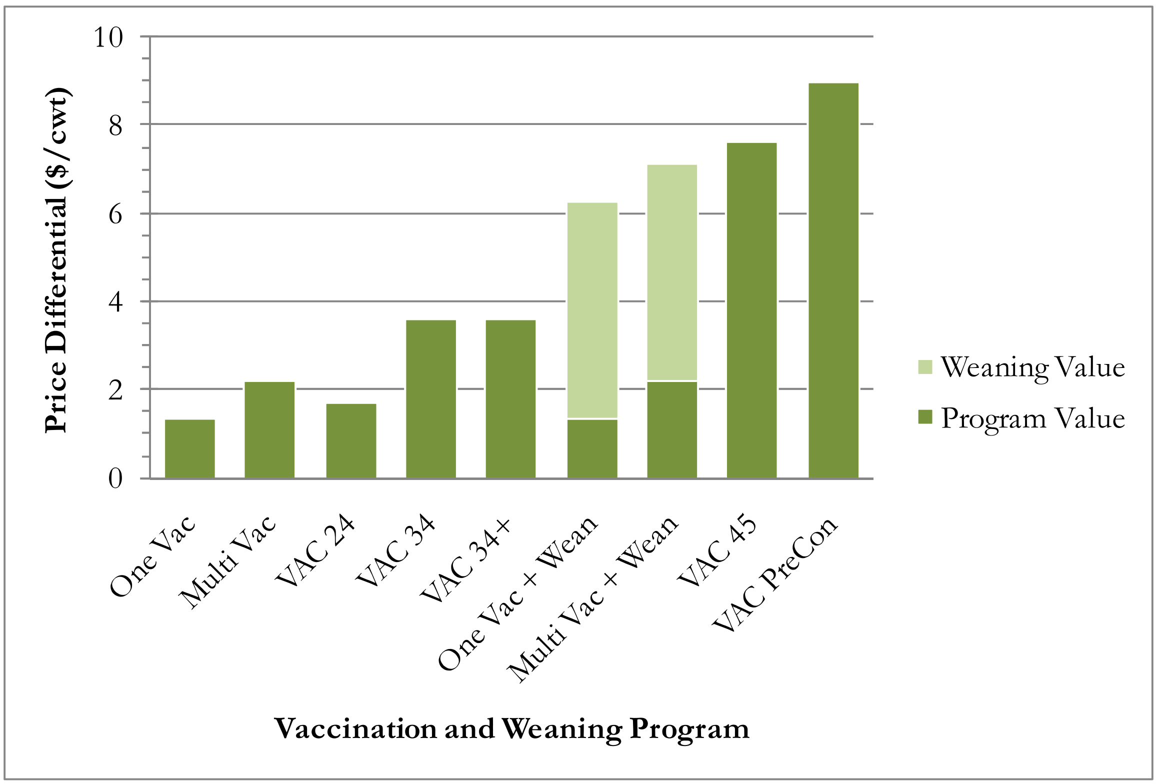
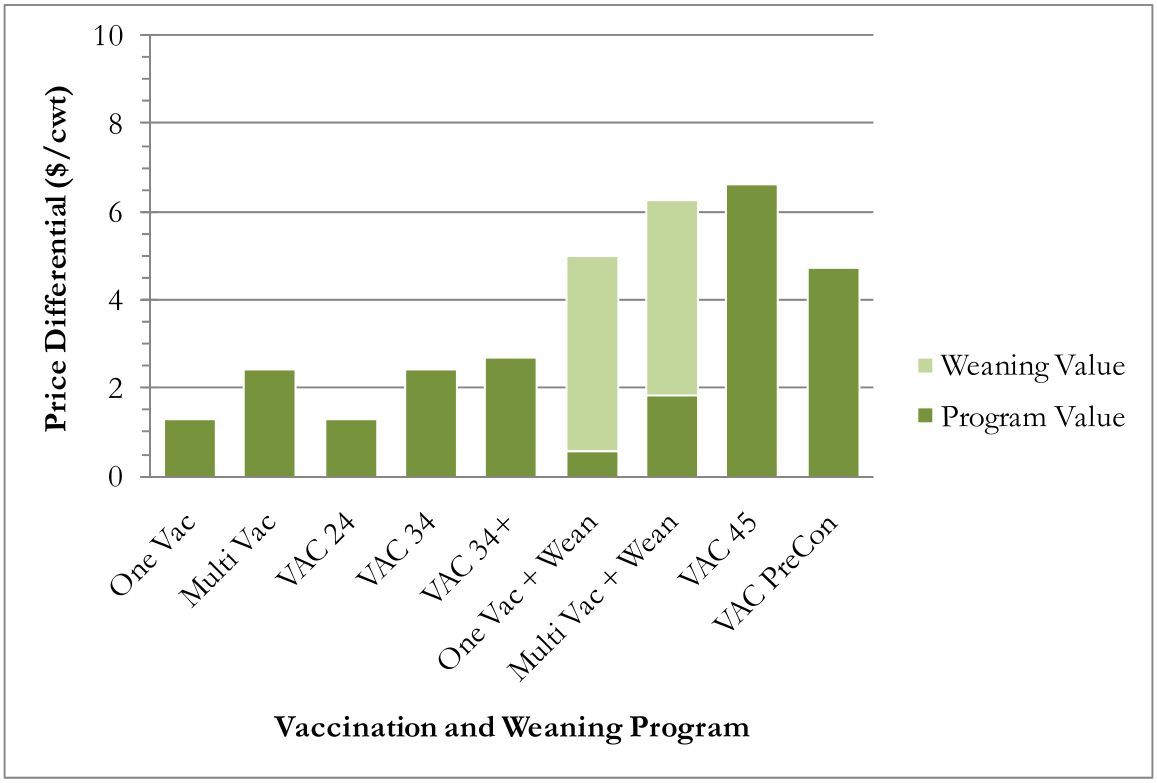


Figure 5.5 - Heifer Vaccination and Weaning Program Value, 2008 to 2009



King et al. (2006) also compared the price effect of vaccination protocols on SLA calf prices. Their model included variables for VAC 24, VAC 34, VAC 45 and non-certified respiratory vaccination programs. The premium for VAC 24 calves was $1.17 per cwt. over non-vaccinated calves, and VAC 34 premiums were $2.45 per cwt. Premium increased as requirements intensified, and the VAC 45 protocol received the highest premium at $6.64 per cwt. Non-program vaccinated calves received a premium of $1.43 per cwt., which was higher than VAC 24 protocol premiums. However, the study did not differentiate between one and multiple respiratory vaccinations.

The price effect for weaning has been explored by two studies. The previous research estimates result in a smaller price effect for weaning compared to this study, but the models also do not appear to separate the effects of weaning from vaccination protocols to the degree of the models estimated here. Kellom et al. (2008) found that weaning added $2.94 per cwt. to the value of Montana feeder calves sold on the SLA video market. Blank et al. (2009) compared the effect of weaning more than 30 days and 30 days or less on the price of calves that sold through Western Video Market. Their study showed that weaning for more than 30 days generated an additional $3.59 per cwt. compared to non-weaned calves, and the price effect for weaning 30 days or less was not statistically different than weaning claims of more than 30 days.

The differences between certified and non-certified vaccination and weaning programs in the model are often subtle. An F-test was used to determine if certification resulted in statistically different price effects for these programs. Table 5.5 highlights the results of individual F-tests and the appropriate equations they represent from Chapter 4. The value of all vaccination programs are considered to be statistically different from each other. As the test is narrowed down to pair-wise comparisons, the test results reveal some similar coefficients.

Both VAC 24 and VAC 34 protocols require only one round of respiratory vaccinations. These observations were compared to calves from non-certified health programs that received one respiratory vaccination. Steer and heifer calves meeting VAC 24 protocol requirements were considered no different statistically than non-certified, one-vaccination calves. However, the market did differentiate between the effect of VAC 34 calves and calves with a single non-certified respiratory vaccination. The price effect for VAC 34+ calves was different depending on gender. The VAC 34+ protocol was new to SLA in 2008, the program requirements were identical to VAC 34 but featured the additional requirement of a booster vaccination two to six weeks prior to shipment. The F-test revealed statistically different price effects for steers meeting VAC 34+ protocol and those with multiple non-certified respiratory vaccinations. The same two vaccination treatments were considered to have similar price effects for heifers at the 95 percent confidence interval. Standards for VAC 45 protocol require calves to be weaned at least 45 days prior to shipment and receive two-rounds of respiratory vaccinations. The non-certified equivalent to this program would be weaned calves receiving multiple respiratory vaccinations. The price effects for these two programs were not statistically different for steers or heifers based on the F-test.

Table 5.5 - Multi-Year Model Vaccination and Weaning Protocol F-test Results, 2008 to 2009

F-test description	Null Hypothesis	Steers		Heifers	
		P-value	Test result	P-value	Test result
All vaccination protocols are equal	(17)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
VAC 24 = One vaccination	(18)	0.3702	Fail to reject H_0	0.2168	Fail to reject H_0
VAC 34 = One vaccination	(19)	< 0.0001	Reject H_0	0.0004	Reject H_0
VAC 34+ = Multiple vaccinations	(20)	0.0038	Reject H_0	0.1549	Fail to reject H_0
VAC 45 = Multiple vaccinations and weaning	(21)	0.1038	Fail to reject H_0	0.2915	Fail to reject H_0

The research estimated the price effect of four additional health-related variables that are new to feeder calf pricing research. Pinkeye and *H. somni* vaccination status were added to SLA lot descriptions in 2008. Cow-calf producers also had the opportunity to list if their calves tested BVD-PI negative starting in the same year. These variables were included in the analysis as well as a variable to estimate the effect of bangs vaccinations on heifer prices. Positive coefficients were expected for each variable since the vaccinations and test were considered to be indicators for lower health risk and better performance and quality in later supply sectors.

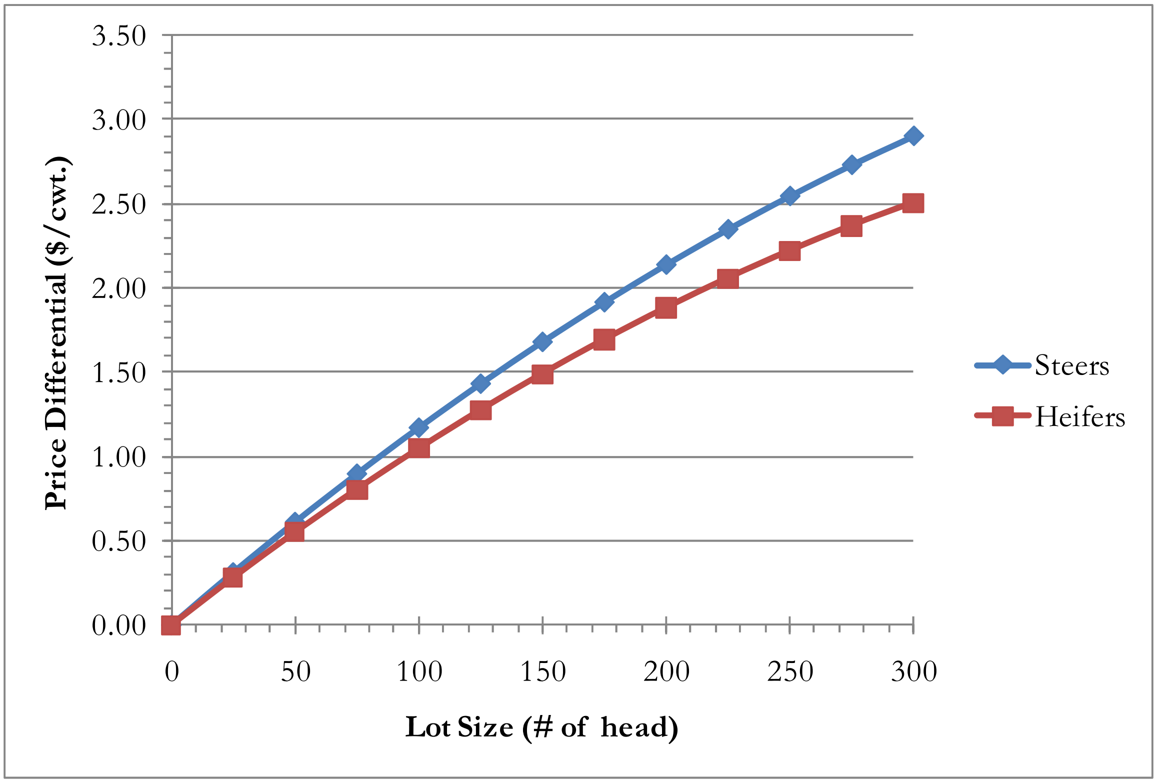
Pinkeye vaccinations were positively correlated with price in the SLA video market. Vaccinated steers received premiums of $1.20 per cwt., and heifers received an additional $1.08 per cwt. Steers vaccinated against *H. somni* received an additional $0.38 per cwt. more than non-vaccinated calves, while the price of *H. somni* vaccinated heifers were not statistically different from non-vaccinated heifers. Calves that tested BVD-PI negative were not discounted or rewarded in the marketplace. The benefit of a BVD-PI test is negated when tested calves come in contact with non-tested BVD carriers. Unless a feedlot tests each calf for BVD, there is no marketplace benefit for tested calves since calves can contract BVD from other disease carriers. Heifers that were bangs vaccinated were discounted $0.53 per cwt. to non-vaccinated contemporaries. Bangs vaccinations are generally reserved for heifers considered to be herd-replacement quality. The expectation was that these calves would also be regarded as high-quality calves for later sectors. There are two possible explanations for the price differential. Buyers may consider these calves as the early culls from a replacement heifer program, and discount them as being inferior to non-vaccinated heifers. The other scenario is that qualities for ideal breeding heifers are in no way related to qualities demanded by the stocker, backgrounding and feedlot sectors. If the later is true, the variable for bangs vaccination is picking up an unknown price effect in the model.

5.1.4 Price Effect of Marketing Characteristics

Marketing characteristics analyzed in the model included variables for lot size, ASV, natural-market eligibility, NHTC-market eligibility, and days between sale and delivery dates. The variables for lot size and feeder cattle futures market contract price represent variables that have been tested thoroughly in previous analyses, while variables used for export and domestic marketing programs are relatively new to feeder calf hedonic pricing models.

Lot size has been considered a relevant feeder calf price determinant since Williamson et al. estimated its effect in 1961. In 1986, Faminow and Gum recognized that hedonic pricing models needed to better capture the non-linear relationship between price and lot size. Their use of a lot-size squared variable proved to be statistically significant in estimating this relationship. Later studies by Schroeder et al. (1988), Lambert et al. (1989), Turner et al. (1991 and 1993) and other agricultural economists would confirm the non-linear relationship in separate hedonic pricing models. The results of this study are no exception. Lot size continued to have a non-linear relationship to price. An illustration of this relationship can be seen in Figure 5.6. It should be noted that the study found heifer lot size in SLA video markets did not have a statistically significant non-linear relationship, which is similar to results from Schroeder et al.

Figure 5.6 - Price-Lot Size Relationship for Steers and Heifers, 2008 to 2009



Estimates from Faminow and Gum (1986), Schroeder et al. (1988) and Sartwelle et al. (1996a) indicated optimal lot sizes ranged from 35 to 75 head depending on calf weight and gender. The premiums available at these optimal lot sizes ranged anywhere from $3.75 to $11.50 per cwt. Their models illustrated a more pronounced non-linear relationship between lot size and price than this research. The quadratic relationship for lot size in this study is still statistically significant for steers in this study, but it is not as distinct as in previous studies. The statistically significant optimal steer lot size in this analysis would be 575 head. More than 60 percent of SLA sale lots are between 50 and 100 head, making optimal lot size an unfeasible goal for most cow-calf producers selling through video markets.

The extreme difference in optimal lot size between this study and previous research was expected considering lot sizes are generally larger in the SLA video market. The average SLA lot size of around 120 head already exceeds the optimal lot sizes in the previously mentioned studies. Turner et al. (1993) noted similar differences in his analysis of Georgia teleauction markets, which had an optimal lot size of 143 head. Bailey et al. (1993) said lot-size adjustments were necessary when comparing video and regional auction markets in joint analysis. Since most SLA video market sale lots are already truckload sized, buyer preferences for lot size are not as apparent when compared to traditional auction markets. The findings from these two studies are consistent with the estimates in this study.

The SLA video market works as a future contract pricing mechanism for feeder calf sellers and buyers. The variable that accounts for the days between the sale and delivery date estimates the effect of price risk on feeder calf sales prices. The coefficient can be interpreted as the dollar per hundredweight change in price for each day between the sale and delivery. Based on the model's coefficient estimates, buyers discounted feeder calves as the difference between sale and delivery increased. Steers and heifers were discounted $0.02 and $0.03 per cwt., respectively, for each additional day between sale and delivery. Since the average sale lot was delivered around 78 days after the sale, the average lot of steers was discounted around $1.56 per cwt. and heifers received $2.34 per cwt. less compared to calves that were delivered immediately. These estimates are consistent with the $0.02 per cwt. discounts applied to lightweight steers and heifers in Bailey et al. (1991). King et al. (2006) reported a more aggressive discount of $0.05 per cwt. for each additional day beyond the sale date.

Age and source verification has been documented in SLA lot descriptions since 2005, and the marketing characteristic generated statistically significant premiums for steers and heifers in the 2008 and 2009 model. Steers with ASV earned an extra $1.58 per cwt. and heifers received an additional $1.66 per cwt. compared to non-ASV calves. King et al. (2006) featured one of the first studies to look at the price effect of ASV calves and discovered a $0.52 per cwt. premium in 2005 SLA video market sales. Montana calves that sold through SLA video markets in June and July 2007 received an additional $2.14 per cwt. in a study by Kellom et al. (2008), while Blank et al. (2009) found calves sold through Western Video Market received an ASV premium of $5.31 per cwt. and yearlings earned an additional $1.96 per cwt. The estimates in the current model fit within the range established with previous research.

Natural and NHTC beef markets have evolved as domestic and international consumers demanded a beef product that meets specific management standards. While excluding cattle from growth-promoting implants is a core component for each program, other production standards must be closely followed to be eligible for these markets. Superior Livestock Auction started noting

Certified Natural Cattle on lot descriptions in 2004 and NHTC in 2008. Calves in these programs can be considered non-implanted, but additional management required that these cattle be distinct from non-implanted calves. The price differentials reported in the model should be interpreted as the dollar per hundredweight difference for program cattle compared to non-implanted calves. Also, sale lots can be designated as meeting the eligibility requirements for both natural and NHTC markets. In these instances, the sum value of the coefficient estimates would equal the total price effect. Natural heifer calves received a statistically significant premium of $0.54 per cwt., while steers received an additional $0.26 per cwt. at the 90 percent confidence level. The premiums for NHTC-eligible steers and heifers were statistically significant and generated an additional $1.51 per cwt. in sales prices. Blank et al. estimated a natural premium of $1.60 per cwt. for Western Video Market calves in 2006. The premiums for natural-eligible calves increased in 2009 to $2.25 per cwt., while yearlings earned an additional $3.78 per cwt. for meeting natural requirements. Research from King et al. (2006) did not find a statistically significant premium for natural calves in SLA video markets in 2005. Previous studies have not estimated the effects of NHTC market requirements on calf sales prices. It is understandable that premiums for these calves would exceed the value of natural-eligible calves since NHTC certification needs to happen at the ranch of origin. Buyers that are willing to take the risk can purchase natural calves from the non-implanted sale population, and work with cow-calf producers to verify past management practices and complete the necessary documentation.

5.1.5 Price Effect of Market Condition Characteristics

The feeder cattle and corn futures market contract prices were used in the initial model as proxy variables for current market conditions in 2008 and 2009 SLA video market sales. However, the initial parameter estimates for these variables produced results that were not consistent with past research. The steer and heifer model estimates for corn were 1.24 and 0.95, while the feeder calf futures price values were 0.50 and 0.54, respectively. Each estimate was considered statistically significant at the 95 percent confidence level. Expectations based on previous research would lead corn futures coefficient estimates that would be negative. In other words, as corn futures market prices increase $1 per bushel, video auction markets would be expected to adjust per hundredweight feeder calf prices lower. Likewise, it is expected that the coefficient estimates for feeder calf futures contract to be closer to one if the video markets efficiently reflect national market conditions in feeder calf prices.

It was suspected that feeder calf futures prices were already reflecting the market signals for the corn market, and the variables were expressing a shared market influence. Corn futures market contract prices were excluded from the final model based on these results, and the coefficient estimates in Table 5.3 reflect this model change. The final estimates for feeder cattle futures market contract prices were 0.7943 for steers and 0.7647 for heifers. Similar estimates were found in Bailey et al. (1991, 1993 and 1995) where steers and heifers sold through SLA video markets had feeder cattle futures estimates ranging from 0.665 to 1.118. Schroeder et al. (1988) found estimates of 0.174 to 0.719 for lightweight steers and heifers sold through Kansas auction markets. An auction market that perfectly reflects the variation of futures markets in feeder calf prices would be reflected with a coefficient estimate value of one for steers that sell at an identical weight range as the feeder cattle contract. An F-test was developed to determine if SLA video market prices could statistically be considered efficient in reflecting futures market conditions. Table 5.6 shows that SLA video markets for steers and heifers are not a perfect reflection of feeder calf price variation compared to national feeder calf futures contract prices.

Table 5.6 - Multi-Year Model Feeder Calf Futures Market F-test Results, 2008 to 2009

F-test description	Null Hypothesis	Steers		Heifers	
		P-value	Test result	P-value	Test result
SLA market efficiency	(22)	< 0.0001	Reject H_0	< 0.0001	Reject H_0

5.2 Results of the 2004 to 2009 Annual SLA Hedonic Pricing Models

The hedonic pricing model from the 2008 to 2009 SLA video auction market show a number of traits have been added to calf lot descriptions in recent years that are relevant to feeder calf prices. Since 2004, SLA has added lot descriptions for Certified Natural Cattle (2004), ASV (2005), Pinkeye vaccination, *H. somni* vaccination, VAC 34+ protocol, BVD-PI negative tested cattle and NHTC (2008). The yearly influence of these management and marketing characteristics on producer participation and calf prices are best examined through an annual analysis.

The 2004 to 2009 annual pricing models were adapted from the 40-variable hedonic model used in the 2008 to 2009 SLA video market analysis. Variables indicating the presence of Pinkeye-vaccinated, *H. somni*-vaccinated, BVD-PI negative, NHTC and ASV calves in the marketplace were excluded from model years when those traits were not reported in lot descriptions. A total of 15,688 steer and 10,358 heifer lots were used to estimate 12 feeder calf hedonic pricing models. The following tables summarize the average price, lot size, weight, sale, delivery and variable information for the sale years analyzed.

Table 5.7 - Average Price, Lot, Weight, Sale and Delivery Data for Steer and Heifer Models, 2004 to 2009

Year	Mean variable	Steers - 450 to 750 lbs.				Heifers - 400 to 700 lbs.			
		Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum
2004	Sale price ($ per cwt.)	$122.68	11.54	$87.50	$157.25	$116.97	11.86	$84.00	$162.50
	Nearby feeder cattle futures contract ($ per cwt.)	$105.25	8.40	$82.45	$117.28	$104.27	9.04	$82.45	$117.28
	Lot size (# of head)	121.12	74.26	30	770	113.84	65.30	35	950
	Base weight (lbs.)	576.66	68.69	450	750	538.42	65.71	400	700
	Sale month (# of month)	6.77	2.24	1	12	6.60	2.44	1	12
	Delivery month (# of month)	9.18	2.62	1	12	8.94	2.86	1	12
	Days to delivery (days between sale and delivery)	75.73	46.45	1	180	73.76	47.20	1	180
2005	Sale price ($ per cwt.)	$124.28	10.43	$97.60	$164.75	$119.14	8.84	$96.00	$158.50
	Nearby feeder cattle futures contract ($ per cwt.)	$107.59	4.18	$96.80	$117.65	$107.64	4.24	$96.80	$117.65
	Lot size (# of head)	121.49	78.77	24	1050	115.64	75.50	38	1100
	Base weight (lbs.)	584.16	70.86	450	750	546.83	66.03	400	700
	Sale month (# of month)	6.77	2.36	1	12	6.60	2.50	1	12
	Delivery month (# of month)	9.06	2.73	1	12	8.84	2.90	1	12
	Days to delivery (days between sale and delivery)	73.15	45.92	0	180	71.29	47.89	1	178
2006	Sale price ($ per cwt.)	$126.41	10.47	$103.00	$170.00	$120.90	9.66	$96.00	$161.00
	Nearby feeder cattle futures contract ($ per cwt.)	$112.81	3.83	$102.90	$119.23	$112.96	3.79	$102.90	$119.23
	Lot size (# of head)	120.63	67.94	50	760	116.48	64.73	40	700
	Base weight (lbs.)	578.57	70.67	450	750	537.72	66.39	400	700
	Sale month (# of month)	7.27	1.06	5	9	7.30	1.07	5	9
	Delivery month (# of month)	9.87	1.35	1	12	9.85	1.44	1	12
	Days to delivery (days between sale and delivery)	80.62	40.76	1	180	79.93	40.85	1	180
2007	Sale price ($ per cwt.)	$122.81	8.87	$97.00	$159.75	$116.44	8.27	$90.75	$149.75
	Nearby feeder cattle futures contract ($ per cwt.)	$115.56	3.06	$106.40	$119.48	$115.63	2.97	$106.40	$119.48
	Lot size (# of head)	122.27	72.21	20	725	114.26	62.45	22	700
	Base weight (lbs.)	582.43	70.38	450	750	541.36	66.25	400	700
	Sale month (# of month)	7.45	0.92	5	9	7.46	0.93	5	9
	Delivery month (# of month)	9.99	1.36	1	12	9.95	1.48	1	12
	Days to delivery (days between sale and delivery)	81.05	36.13	2	180	80.46	37.11	2	177
2008	Sale price ($ per cwt.)	$115.14	8.58	$84.50	$144.50	$107.48	7.62	$78.50	$145.00
	Nearby feeder cattle futures contract ($ per cwt.)	$113.52	2.50	$106.38	$117.30	$113.47	2.62	$106.38	$117.30
	Lot size (# of head)	126.90	81.35	25.00	1000.00	116.81	73.05	20.00	1000.00
	Base weight (lbs.)	582.85	70.17	450.00	750.00	543.42	65.79	400.00	700.00
	Sale month (# of month)	7.44	0.85	6	9	7.46	0.88	6	9
	Delivery month (# of month)	9.97	1.37	1	12	9.95	1.50	1	12
	Days to delivery (days between sale and delivery)	77.40	37.24	0	180	77.43	37.99	0	180
2009	Sale price ($ per cwt.)	$105.58	7.60	$80.50	$140.00	$98.11	6.81	$77.00	$135.00
	Nearby feeder cattle futures contract ($ per cwt.)	$101.43	1.48	$96.55	$103.45	$101.43	1.52	$96.55	$103.45
	Lot size (# of head)	122.31	75.87	38	1165	115.48	69.52	35	910
	Base weight (lbs.)	583.31	67.97	450	750	545.45	64.71	400	700
	Sale month (# of month)	7.44	0.84	6	9	7.42	0.84	6	9
	Delivery month (# of month)	10.01	1.37	1	12	10.01	1.44	1	12
	Days to delivery (days between sale and delivery)	77.94	36.34	1	170	78.77	36.31	2	178

Table 5.8 - Means for Steer Hedonic Pricing Models, 2004 to 2009

Characteristic	Variable Description	2004		2005		2006		2007		2008		2009	
		Observations		Observations		Observations		Observations		Observations		Observations	
		(# of lots)	(% of lots)	(# of lots)	(% of lots)	(# of lots)	(% of lots)	(# of lots)	(% of lots)	(# of lots)	(% of lots)	(# of lots)	(% of lots)
Frame	Small to medium	1252	41.76%	1324	38.61%	880	41.96%	1055	44.67%	1025	42.94%	1072	44.39%
	Medium to medium-large mix	1348	44.96%	1615	47.10%	970	46.26%	1033	43.73%	1064	44.57%	1058	43.81%
	Medium-large to large	398	13.28%	490	14.29%	247	11.78%	274	11.60%	298	12.48%	285	11.80%
Flesh	Light to light-medium	182	6.07%	195	5.69%	77	3.67%	87	3.68%	114	4.78%	108	4.47%
	Light-medium to medium mix	252	8.41%	286	8.34%	140	6.68%	123	5.21%	165	6.91%	162	6.71%
	Medium	2490	83.06%	2825	82.39%	1806	86.12%	2082	88.15%	2043	85.59%	2082	86.21%
	Medium to medium-heavy mix to heavy	74	2.47%	123	3.59%	74	3.53%	70	2.96%	65	2.72%	63	2.61%
Weight variation	Even to fairly even	231	7.71%	244	7.12%	140	6.68%	169	7.15%	171	7.16%	158	6.54%
(uniformity)	Uneven	2640	88.06%	3055	89.09%	1889	90.08%	2106	89.16%	2125	89.02%	2167	89.73%
	Very uneven	127	4.24%	130	3.79%	68	3.24%	87	3.68%	91	3.81%	90	3.73%
Implant	Not implanted	1173	39.13%	1373	40.04%	656	31.28%	810	34.29%	862	36.11%	883	36.56%
	Natural eligible - Not implanted	630	21.01%	785	22.89%	747	35.62%	848	35.90%	764	32.01%	768	31.80%
	NHTC eligible - Not implanted		0.00%		0.00%					32	1.34%	50	2.07%
	Unknown or some implanted	75	2.50%	90	2.62%	49	2.34%	68	2.88%	83	3.48%	94	3.89%
	Implanted	1120	37.36%	1181	34.44%	645	30.76%	636	26.93%	668	27.98%	648	26.83%
Vaccination	Not vaccinated	113	3.77%	94	2.74%	59	2.81%	78	3.30%	58	2.43%	39	1.61%
	VAC 24	163	5.44%	223	6.50%	201	9.59%	237	10.03%	247	10.35%	223	9.23%
	VAC 34	1048	34.96%	1242	36.22%	1057	50.41%	1197	50.68%	869	36.41%	762	31.55%
	VAC 34+				0.00%					324	13.57%	471	19.50%
	VAC 45	591	19.71%	652	19.01%	486	23.18%	575	24.34%	496	20.78%	566	23.44%
	VAC Precon	128	4.27%	233	6.79%	83	3.96%	86	3.64%	46	1.93%	62	2.57%
	One respiratory vaccination	525	17.51%	503	14.67%	169	8.06%	144	6.10%	156	6.54%	113	4.68%
	Two or more respiratory vaccinations	430	14.34%	482	14.06%	42	2.00%	45	1.91%	191	8.00%	179	7.41%
Weaning	Weaned calves	1267	42.26%	1486	43.34%	569	27.13%	661	27.98%	742	31.09%	809	33.50%
	Weaning w/ respiratory vaccination	548	18.28%	601	17.53%					200	8.38%	179	7.41%
Pinkeye vaccinated	Vaccinated									124	5.19%	109	4.51%
***H. somni* vaccinated**	Vaccinated									521	21.83%	538	22.28%
BVD PI-Negative	Tested									104	4.36%	72	2.98%
Age-and-source vaccinated	Calves enrolled in program			225	6.56%	280	13.35%	394	16.68%	727	30.46%	1083	44.84%
Horns	Some, tipped and all horns	407	13.58%	512	14.93%	120	5.72%	114	4.83%	125	5.24%	130	5.38%
Breed	Cattle w/ ear	843	28.12%	956	27.88%	352	16.79%	344	14.56%	396	16.59%	365	15.11%
	English & English cross	252	8.41%	302	8.81%	251	11.97%	279	11.81%	260	10.89%	246	10.19%
	Continental & Continental cross	48	1.60%	47	1.37%	34	1.62%	32	1.35%	44	1.84%	57	2.36%
	English/Continental cross	1164	38.83%	1274	37.15%	753	35.91%	852	36.07%	808	33.85%	801	33.17%
	Black & black-white-faced	556	18.55%	700	20.41%	581	27.71%	713	30.19%	723	30.29%	782	32.38%
	Predominantly Angus	135	4.50%	150	4.37%	126	6.01%	144	6.10%	156	6.54%	164	6.79%
Region of origin	West	461	15.38%	561	16.36%	409	19.50%	482	20.41%	577	24.17%	622	25.76%
	Rocky Mountain/North Central	1302	43.43%	1390	40.54%	1090	51.98%	1244	52.67%	1166	48.85%	1153	47.74%
	South Central	995	33.19%	1230	35.87%	474	22.60%	502	21.25%	480	20.11%	494	20.46%
	Southeast	240	8.01%	248	7.23%	124	5.91%	134	5.67%	164	6.87%	146	6.05%

Table 5.9 - Means for Heifer Hedonic Pricing Models, 2004 to 2009

Characteristic	Variable	2004		2005		2006		2007		2008		2009	
		Observations		Observations		Observations		Observations		Observations		Observations	
		(# of lots)	(% of lots)	(# of lots)	(% of lots)	(# of lots)	(% of lots)	(# of lots)	(% of lots)	(# of lots)	(% of lots)	(# of lots)	(% of lots)
Frame	Small to medium	947	43.46%	992	41.80%	566	44.12%	686	45.61%	670	44.52%	682	45.05%
	Medium to medium-large mix	1017	46.67%	1126	47.45%	582	45.36%	653	43.42%	658	43.72%	632	41.74%
	Medium-large to large	215	9.87%	255	10.75%	135	10.52%	165	10.97%	177	11.76%	200	13.21%
Flesh	Light to light-medium	137	6.29%	135	5.69%	65	5.07%	63	4.19%	67	4.45%	71	4.69%
	Light-medium to medium mix	213	9.78%	227	9.57%	85	6.63%	95	6.32%	127	8.44%	112	7.40%
	Medium	1788	82.06%	1934	81.50%	1097	85.50%	1314	87.37%	1275	84.72%	1291	85.27%
	Medium to medium-heavy mix to heavy	41	1.88%	77	3.24%	36	2.81%	32	2.13%	36	2.39%	40	2.64%
Weight variation	Even to fairly even	162	7.43%	134	5.65%	70	5.46%	76	5.05%	89	5.91%	85	5.61%
(uniformity)	Uneven	1920	88.11%	2124	89.51%	1161	90.49%	1360	90.43%	1351	89.77%	1366	90.22%
	Very uneven	97	4.45%	115	4.85%	52	4.05%	68	4.52%	65	4.32%	63	4.16%
Implant	Not implanted	1034	47.45%	1229	51.79%	495	38.58%	611	40.63%	618	41.06%	629	41.55%
	Natural eligible - Not implanted	492	22.58%	494	20.82%	465	36.24%	530	35.24%	510	33.89%	522	34.48%
	NHTC eligible - Not implanted									29	1.93%	48	3.17%
	Unknown or some implanted	66	3.03%	79	3.33%	40	3.12%	60	3.99%	69	4.58%	74	4.89%
	Implanted	587	26.94%	571	24.06%	283	22.06%	303	20.15%	299	19.87%	268	17.70%
Vaccination	Not vaccinated	85	3.90%	55	2.32%	35	2.73%	63	4.19%	42	2.79%	16	1.06%
	VAC 24	108	4.96%	124	5.23%	120	9.35%	149	9.91%	163	10.83%	164	10.83%
	VAC 34	687	31.53%	797	33.59%	636	49.57%	744	49.47%	528	35.08%	481	31.77%
	VAC 34+									196	13.02%	269	17.77%
	VAC 45	421	19.32%	447	18.84%	302	23.54%	381	25.33%	323	21.46%	367	24.24%
	VAC Precon	82	3.76%	147	6.19%	59	4.60%	38	2.53%	14	0.93%	18	1.19%
	One respiratory vaccination	459	21.06%	414	17.45%	102	7.95%	103	6.85%	108	7.18%	79	5.22%
	Two or more respiratory vaccinations	337	15.47%	389	16.39%	29	2.26%	26	1.73%	131	8.70%	120	7.93%
Weaning	Weaned calves	995	45.66%	1129	47.58%	361	28.14%	419	27.86%	488	32.43%	524	34.61%
	Weaning w/ respiratory vaccination	492	22.58%	535	22.55%					151	10.03%	139	9.18%
Pinkeye vaccinated	Vaccinated									85	5.65%	66	4.36%
***H. somni* vaccinated**	Vaccinated									336	22.33%	327	21.60%
BVD PI-Negative	Tested									68	4.52%	51	3.37%
Bangs vaccinated	Vaccinated	358	16.43%							267	17.74%	292	19.29%
Age-and-source vaccinated	Calves enrolled in program			141	5.94%	169	13.17%	243	16.16%	453	30.10%	672	44.39%
Horns	Some, tipped and all horns	370	16.98%	472	19.89%	104	8.11%	78	5.19%	89	5.91%	95	6.27%
Breed	Cattle w/ ear	695	31.90%	772	32.53%	251	19.56%	260	17.29%	251	16.68%	249	16.45%
	English & English cross	150	6.88%	167	7.04%	135	10.52%	161	10.70%	155	10.30%	132	8.72%
	Continental & Continental cross	30	1.38%	30	1.26%	22	1.71%	28	1.86%	43	2.86%	46	3.04%
	English/Continental cross	854	39.19%	910	38.35%	501	39.05%	557	37.03%	538	35.75%	537	35.47%
	Black & black-white-faced	355	16.29%	427	17.99%	319	24.86%	417	27.73%	428	28.44%	470	31.04%
	Predominantly Angus	95	4.36%	67	2.82%	55	4.29%	81	5.39%	90	5.98%	80	5.28%
Region of origin	West	346	15.88%	381	16.06%	240	18.71%	327	21.74%	397	26.38%	423	27.94%
	Rocky Mountain/North Central	881	40.43%	900	37.93%	645	50.27%	767	51.00%	693	46.05%	679	44.85%
	South Central	736	33.78%	899	37.88%	330	25.72%	306	20.35%	319	21.20%	316	20.87%
	Southeast	216	9.91%	193	8.13%	68	5.30%	104	6.91%	96	6.38%	96	6.34%

Steers calves from 2004 to 2009 SLA video market sales ranged from $105.58 per cwt. in 2009 to $126.41 per cwt. in 2006. The average lot size during these years remained relatively stable, fluctuating between 120 to 125 head per sale lot. Average base weight reached a high of 584 lbs. in 2005, but the range remained between 577 to 584 lbs. over the six years. Heifers consistently received $5 to $8 per cwt. less than steers on the SLA video market from 2004 to 2009 with a price range of $98.11 to $120.90 per cwt. Similar to steers, 2009 represented the low annual average price for heifers and 2006 was the high, and annual average lot sizes were consistently around 110 to 115 head.

In 2006, Pfizer Animal Health changed their video market data collection to only include calf sales from the six to eight largest SLA sales (King 2010). Data from 2004 and 2005 includes year-round sale information. In 2006 and 2007, only May to September video market sales were recorded. The recorded sale months were reduced an additional month to only June to September sales for 2008 and 2009. The data collection changes resulted in around 600 less observations for the 2006 to 2009 models compared to the preceding two years. The changes resulted in a noticeable population shift for vaccinated calves (Table 5.8 and Table 5.9). In 2006 and 2007, there were no weaned steer or heifer calves on record as receiving respiratory vaccinations in a non-certified program. These observations reappeared in the 2008 and 2009 sale data, but at a substantially lower rate than 2004 and 2005. A variable representing weaned calves with non-certified respiratory vaccinations could not be estimated for 2006 and 2007 due to these changes.

Summaries of the coefficient estimates from 2004 to 2009 annual hedonic pricing models are reported in the following four tables. Estimated steer models accounted for 72 to 84 percent of the price variation in SLA video market sales. Heifer pricing models showed similar reliability with 58 to 84 percent of the price variation explained by the models. Heteroskedasticity was detected in all steer models and half of the heifer models at the 95 percent confidence level. White standard errors were used to determine the P-values in these models. Heifer pricing models for 2004, 2006 and 2007 were statistically homoskedastic, and OLS standard errors were used in the calculation of P-values for each coefficient. Each model was analyzed for collinearity and degrading collinearity was not a concern in any of the hedonic models.

Table 5.10 - Coefficients Estimates for Steer Hedonic Pricing Models, 2004 to 2009

Characteristic	Variable description	2004 Observ. (lots)	2004 Coefficient ($/cwt.)	2004 P-Value (P>|t|)	2005 Observ. (lots)	2005 Coefficient ($/cwt.)	2005 P-Value (P>|t|)	2006 Observ. (lots)	2006 Coefficient ($/cwt.)	2006 P-Value (P>|t|)
Intercept	Intercept	2998	174.4479	< 0.0001	3429	256.8745	< 0.0001	2097	249.4400	< 0.0001
Lot size	Number of head	2998	0.0235	< 0.0001	3429	0.0177	< 0.0001	2097	0.0160	0.0014
(Lot size)^2	Number of head squared	2998	-0.00003	< 0.0001	3429	-0.00002	0.0002	2097	-0.00001	0.4786
Weight	Average base weight of lot	2998	-0.3975	< 0.0001	3429	-0.5412	< 0.0001	2097	-0.4815	< 0.0001
(Weight)^2	Average base weight of lot squared	2998	0.00025	< 0.0001	3429	0.00036	< 0.0001	2097	0.00032	< 0.0001
Frame	Small to medium	1252	-0.5810	0.0027	1324	-0.5552	0.0042	880	-0.2756	0.2418
	Medium to medium-large mix	1348	Base		1615	Base		970	Base	
	Medium-large to large	398	0.4601	0.0905	490	0.1162	0.652	247	0.0605	0.8656
Flesh	Light to light-medium	182	0.6311	0.1786	195	0.7546	0.0617	77	0.4668	0.4641
	Light-medium to medium mix	252	1.1366	0.005	286	2.2450	< 0.0001	140	1.3595	0.0095
	Medium	2490	Base		2825	Base		1806	Base	
	Medium to medium-heavy mix to heavy	74	-0.6194	0.2489	123	-1.7797	< 0.0001	74	-1.4693	0.0054
Weight variation	Even to fairly even	231	1.4195	< 0.0001	244	1.0086	0.0017	140	0.8231	0.0289
(uniformity)	Uneven	2640	Base		3055	Base		1889	Base	
	Very uneven	127	-1.1993	0.008	130	-1.2177	0.0134	68	-0.6557	0.255
Implant	Not implanted	1173	Base		1373	Base		656	Base	
	Natural eligible - Not implanted	630	1.1730	< 0.0001	785	-0.0456	0.8439	747	0.9286	0.0006
	NHTC eligible - Not implanted									
	Unknown or some implanted	75	-1.0654	< 0.0001	90	0.0697	0.7403	49	-0.6008	0.0337
	Implanted	1120	0.3747	0.4773	1181	0.6229	0.3042	645	-0.1718	0.8024
Vaccination	Not vaccinated	113	Base		94	Base		59	Base	
	VAC 24	163	1.7099	< 0.0001	223	2.8468	< 0.0001	201	0.9534	0.1193
	VAC 34	1048	3.0716	< 0.0001	1242	3.3659	< 0.0001	1057	2.7155	< 0.0001
	VAC 34+									
	VAC 45	591	6.8159	< 0.0001	652	6.0322	< 0.0001	486	7.2242	< 0.0001
	VAC Precon	128	6.0595	< 0.0001	233	7.0940	< 0.0001	83	5.7969	< 0.0001
	One respiratory vaccination	525	1.7464	< 0.0001	503	2.1360	< 0.0001	169	0.8941	0.0816
	Two or more respiratory vaccinations	430	2.9764	< 0.0001	482	2.7722	< 0.0001	42	2.1456	0.0198
	Weaning w/ respiratory vaccination	548	2.7060	0.0002	601	3.4275	< 0.0001			
Pinkeye vaccinated	Not vaccinated or unknown									
	Vaccinated									
***H. somni* vaccinated**	Not vaccinated or unknown									
	Vaccinated at least once									
BVD PI-Negative	No									
	Yes									
Age-and-source vaccinated	No				3204	Base		1817	Base	
	Yes				225	0.9191	0.0454	280	2.0376	< 0.0001
Horns	No horns	2591	Base		2917	Base		1977	Base	
	Some, tipped and all horns	407	-0.7127	< 0.0001	512	-1.0880	< 0.0001	120	1.1773	< 0.0001
Breed	Cattle w/ ear	843	Base		956	Base		352	Base	
	English & English cross	252	4.3797	< 0.0001	302	3.6378	< 0.0001	251	5.2051	< 0.0001
	Continental & Continental cross	48	3.5665	< 0.0001	47	2.9115	< 0.0001	34	5.0560	< 0.0001
	English/Continental cross	1164	4.2686	< 0.0001	1274	3.2434	< 0.0001	753	5.4354	< 0.0001
	Black & black-white-faced	556	5.9264	< 0.0001	700	4.7462	< 0.0001	581	7.5527	< 0.0001
	Predominantly Angus	135	5.9874	< 0.0001	150	6.2168	< 0.0001	126	7.4140	< 0.0001
Price variation	Feeder cattle futures price	2998	0.7659	< 0.0001	3429	0.4582	< 0.0001	2097	0.3424	< 0.0001
Region of origin	West	461	-1.2877	< 0.0001	561	-5.5671	< 0.0001	409	-2.7706	< 0.0001
	Rocky Mountain/North Central	1302	0.7531	< 0.0001	1390	-0.2880	< 0.0001	1090	2.4682	< 0.0001
	South Central	995	Base		1230	Base		474	Base	
	Southeast	240	-4.6584	< 0.0001	248	-2.8224	< 0.0001	124	-4.0090	< 0.0001
Days to delivery	Days between sale and delivery date	2998	0.0250	< 0.0001	3429	0.0184	< 0.0001	2097	-0.0272	< 0.0001

Analysis of Variance and Homoskedasticity	2004	2005	2006
	Adj. R^2 Value: *0.8371*	***Adj. R^2 Value:*** *0.7722*	***Adj. R^2 Value:*** *0.7940*
	Root MSE: *4.65891*	***Root MSE:*** *4.97948*	***Root MSE:*** *4.75133*
	White Test Results:	***White Test Results:***	***White Test Results:***
	$P>Chi^2$ *= 0.0098*	$P>Chi^2$ *<0.0001*	$P>Chi^2$ *= 0.0351*
	DF = 476, Chi-Square = 550.97	*DF = 511, Chi-Square = 660.94*	*DF = 468, Chi-Square = 524.90*

(Continued)

Table 5.10 - Coefficients Estimates for Steer Hedonic Pricing Models, 2004 to 2009 - Continued

Characteristic	Variable description	2007			2008			2009		
		Observ. (lots)	Coefficient ($/cwt.)	P-Value (P>|t|)	Observ. (lots)	Coefficient ($/cwt.)	P-Value (P>|t|)	Observ. (lots)	Coefficient ($/cwt.)	P-Value (P>|t|)
Intercept	Intercept	2362	242.7521	< 0.0001	2387	183.7044	< 0.0001	2415	175.4978	< 0.0001
Lot size	Number of head	2362	0.0118	0.0019	2387	0.0089	0.0009	2415	0.0158	< 0.0001
(Lot size)^2	Number of head squared	2362	-0.00001	0.436	2387	-0.000003	0.4958	2415	-0.00002	< 0.0001
Weight	Average base weight of lot	2362	-0.4911	< 0.0001	2387	-0.3600	< 0.0001	2415	-0.3939	< 0.0001
(Weight)^2	Average base weight of lot squared	2362	0.00034	< 0.0001	2387	0.00025	< 0.0001	2415	0.00027	< 0.0001
Frame	Small to medium	1055	-0.7643	< 0.0001	1025	-0.6758	0.0014	1072	-0.2372	0.2073
	Medium to medium-large mix	1033	Base		1064	Base		1058	Base	
	Medium-large to large	274	-0.1030	0.6926	298	-0.5281	0.0634	285	-0.0210	0.9336
Flesh	Light to light-medium	87	-697.1690	0.703	114	0.0837	0.837	108	0.6795	0.1007
	Light-medium to medium mix	123	0.5649	0.2293	165	0.4566	0.2478	162	0.9003	0.0244
	Medium	2082	Base		2043	Base		2082	Base	
	Medium to medium-heavy mix to heavy	70	-1.3581	0.0021	65	0.4357	0.4656	63	-0.3805	0.522
Weight variation	Even to fairly even	169	0.8740	0.0088	171	0.2132	0.5381	158	0.8595	0.0087
(uniformity)	Uneven	2106	Base		2125	Base		2167	Base	
	Very uneven	87	-0.1650	0.6972	91	-0.0067	0.9917	90	0.0388	0.9361
Implant	Not implanted	810	Base		862	Base		883	Base	
	Natural eligible - Not implanted	848	0.3301	0.116	764	0.4891	0.0283	768	0.1128	0.574
	NHTC eligible - Not implanted				32	2.6962	0.0021	50	0.4144	0.4981
	Unknown or some implanted	68	-0.0293	0.8975	83	-1.3526	0.0161	94	-1.6362	0.0002
	Implanted	636	-0.0261	0.9623	668	-0.1225	0.6169	648	0.5232	0.0115
Vaccination	Not vaccinated	78	Base		58	Base		39	Base	
	VAC 24	237	2.0512	< 0.0001	247	1.4917	0.0575	223	1.8121	0.0438
	VAC 34	1197	4.1500	< 0.0001	869	3.7515	< 0.0001	762	3.6072	< 0.0001
	VAC 34+				324	3.5659	< 0.0001	471	3.7090	< 0.0001
	VAC 45	575	6.6907	< 0.0001	496	7.9035	< 0.0001	566	6.8070	< 0.0001
	VAC Precon	86	10.5594	< 0.0001	46	10.7187	< 0.0001	62	7.4953	< 0.0001
	One respiratory vaccination	144	1.1472	0.0051	156	1.6575	0.0504	113	0.8655	0.3827
	Two or more respiratory vaccinations	45	2.2047	0.0059	191	2.4735	0.0096	179	1.4468	0.1812
	Weaning w/ respiratory vaccination				200	4.6260	< 0.0001	181	5.0966	< 0.0001
Pinkeye vaccinated	Not vaccinated or unknown				2263	Base		2306	Base	
	Vaccinated				124	0.7567	0.0622	109	1.5453	0.0002
***H. somni* vaccinated**	Not vaccinated or unknown				1866	Base		1877	Base	
	Vaccinated at least once				521	0.1801	0.4211	538	0.4484	0.0256
BVD PI-Negative	No				2283	Base		2343	Base	
	Yes				104	-0.3235	0.5182	72	0.2563	0.6242
Age-and-source vaccinated	No	1968	Base		1660	Base		1332	Base	
	Yes	394	1.5123	< 0.0001	727	1.9625	< 0.0001	1083	1.4686	< 0.0001
Horns	No horns	2248	Base		2262	Base		2285	Base	
	Some, tipped and all horns	114	-0.2138	< 0.0001	125	-0.8994	0.1157	130	-0.4783	0.3406
Breed	Cattle w/ ear	344	Base		396	Base		365	Base	
	English & English cross	277	3.7959	< 0.0001	260	4.3509	< 0.0001	246	3.8394	< 0.0001
	Continental & Continental cross	32	3.4028	< 0.0001	44	4.2262	< 0.0001	57	3.7006	< 0.0001
	English/Continental cross	852	3.5215	< 0.0001	808	4.4848	< 0.0001	801	3.5021	< 0.0001
	Black & black-white-faced	713	5.1526	< 0.0001	723	6.3348	< 0.0001	782	5.1163	< 0.0001
	Predominantly Angus	144	5.8612	< 0.0001	156	6.6843	< 0.0001	164	6.0499	< 0.0001
Price variation	Feeder cattle futures price	2362	0.3513	< 0.0001	2387	0.4208	< 0.0001	2415	0.5564	< 0.0001
Region of origin	West	482	-3.4328	< 0.0001	577	-4.7354	< 0.0001	622	-2.6024	< 0.0001
	Rocky Mountain/North Central	1244	1.8625	< 0.0001	1166	0.8753	0.0188	1153	1.0412	0.0007
	South Central	502	Base		480	Base		494	Base	
	Southeast	134	-6.1958	< 0.0001	164	-10.6083	< 0.0001	146	-6.4408	< 0.0001
Days to delivery	Days between sale and delivery date	2362	-0.0186	< 0.0001	2387	-0.0156	< 0.0001	2415	-0.0078	0.0099
Analysis of Variance and Homoskedasticity		***Adj. R^2 Value:*** *0.7888*			***Adj. R^2 Value:*** *0.7195*			***Adj. R^2 Value:*** *0.7216*		
		Root MSE: *4.07505*			***Root MSE:*** *4.54441*			***Root MSE:*** *4.00850*		
		White Test Results:			***White Test Results:***			***White Test Results:***		
		$P>Chi^2$ = 0.0043			*$P>Chi^2$ <0.0001*			*$P>Chi^2$ = 0.0225*		
		DF = 471, Chi-Square = 555.56			*DF = 667, Chi-Square = 856.35*			*DF = 674, Chi-Square = 749.58*		

Table 5.11 - Coefficients Estimates for Heifer Hedonic Pricing Models, 2004 to 2009

Characteristic	Variable description	2004			2005			2006		
		Observ. (lots)	Coefficient ($/cwt.)	P-Value (P>|t|)	Observ. (lots)	Coefficient ($/cwt.)	P-Value (P>|t|)	Observ. (lots)	Coefficient ($/cwt.)	P-Value (P>|t|)
Intercept	Intercept	2179	150.4457	< 0.0001	2373	211.2834	< 0.0001	1283	214.0841	< 0.0001
Lot size	Number of head	2179	0.0177	< 0.0001	2373	0.0174	< 0.0001	1283	0.0365	< 0.0001
(Lot size)^2	Number of head squared	2179	-0.00002	0.0093	2373	-0.00002	0.0057	1283	-0.00005	< 0.0001
Weight	Average base weight of lot	2179	-0.3508	< 0.0001	2373	-0.3953	< 0.0001	1283	-0.4360	< 0.0001
(Weight)^2	Average base weight of lot squared	2179	0.00023	< 0.0001	2373	0.00027	< 0.0001	1283	0.00031	< 0.0001
Frame	Small to medium	947	-0.6322	0.0051	992	-0.6150	0.0068	566	-0.7588	0.0081
	Medium to medium-large mix	1017	Base		1126	Base		582	Base	
	Medium-large to large	215	-0.0017	0.9964	255	-0.0564	0.8701	135	0.0099	0.9823
Flesh	Light to light-medium	137	1.8220	< 0.0001	135	1.8784	0.0008	65	0.7839	0.2041
	Light-medium to medium mix	213	0.0532	0.887	227	1.4364	0.0003	85	1.1872	0.0308
	Medium	1788	Base		1934	Base		1097	Base	
	Medium to medium-heavy mix to heavy	41	0.5904	0.4386	77	-1.7825	0.0004	36	-1.0450	0.1925
Weight variation	Even to fairly even	162	2.3332	< 0.0001	134	2.7074	< 0.0001	70	2.6922	< 0.0001
(uniformity)	Uneven	1920	Base		2124	Base		1161	Base	
	Very uneven	97	-1.0634	0.0335	115	-1.5937	0.0028	52	-1.5399	0.0239
Implant	Not implanted	1034	Base		1229	Base		495	Base	
	Natural eligible - Not implanted	492	1.4678	< 0.0001	494	-0.2288	0.4185	465	1.4105	< 0.0001
	NHTC eligible - Not implanted									
	Unknown or some implanted	66	0.4863	0.4223	79	-0.5362	0.0396	40	-0.0456	0.9527
	Implanted	587	-0.0257	0.9249	571	-0.2429	0.7759	283	-0.1791	0.6341
Vaccination	Not vaccinated	85	Base		55	Base		35	Base	
	VAC 24	108	1.8548	0.0076	124	2.1462	0.0036	120	1.1661	0.1932
	VAC 34	687	2.4750	< 0.0001	797	1.9082	0.0133	636	2.1468	0.0086
	VAC 34+									
	VAC 45	421	5.5291	< 0.0001	447	4.4214	< 0.0001	302	5.8447	< 0.0001
	VAC Precon	82	2.3832	0.0023	147	4.3616	< 0.0001	59	4.3877	< 0.0001
	One respiratory vaccination	459	0.5327	0.3807	414	1.2566	0.0093	102	1.0266	0.2638
	Two or more respiratory vaccinations	337	1.2611	0.0621	389	1.7119	0.001	29	1.7159	0.1445
	Weaning w/ respiratory vaccination	492	2.9669	< 0.0001	535	2.8954	0.0007			
Pinkeye vaccinated	Not vaccinated or unknown									
	Vaccinated									
***H. somni* vaccinated**	Not vaccinated or unknown									
	Vaccinated at least once									
BVD PI-Negative	No									
	Yes									
Bangs vaccinated	Not vaccinated or unknown	1821	Base							
	Vaccinated	358	1.0768	0.0019						
Age-and-source vaccinated	No				2232	Base		1114	Base	
	Yes				141	0.8963	< 0.0001	169	1.4972	0.0002
Horns	No horns	1809	Base		1901	Base		1179	Base	
	Some, tipped and all horns	370	-0.3834	0.2657	472	-0.8291	< 0.0001	104	-1.0280	0.0718
Breed	Cattle w/ ear	695	Base		772	Base		251	Base	
	English & English cross	150	3.4777	< 0.0001	167	3.3667	< 0.0001	135	4.7127	< 0.0001
	Continental & Continental cross	30	2.2684	< 0.0001	30	1.2047	0.0034	22	2.4721	0.0249
	English/Continental cross	854	3.2914	0.0145	910	2.5928	0.0061	501	3.6352	< 0.0001
	Black & black-white-faced	355	5.0872	< 0.0001	427	4.4133	< 0.0001	319	5.8977	< 0.0001
	Predominantly Angus	95	7.3918	< 0.0001	67	8.2046	< 0.0001	55	6.4957	< 0.0001
Price variation	Feeder cattle futures price	2179	0.7497	< 0.0001	2373	0.3332	< 0.0001	1283	0.3686	< 0.0001
Region of origin	West	346	-1.4617	0.0007	381	-4.4898	< 0.0001	240	-1.8599	0.0001
	Rocky Mountain/North Central	881	1.2301	0.0003	900	-0.0193	< 0.0001	645	2.3751	< 0.0001
	South Central	736	Base		899	Base		330	Base	
	Southeast	216	-3.6801	< 0.0001	193	-2.1704	< 0.0001	68	-4.6076	< 0.0001
Days to delivery	Days between sale and delivery date	2179	0.0194	< 0.0001	2373	0.0124	< 0.0001	1283	-0.0254	< 0.0001
		Adj. R^2 Value: *0.8427*			***Adj. R^2 Value:*** *0.6849*			***Adj. R^2 Value:*** *0.7749*		
		Root MSE: *4.70534*			***Root MSE:*** *4.96106*			***Root MSE:*** *4.58157*		
Analysis of Variance and Homoskedasticity		***White Test Results:***			***White Test Results:***			***White Test Results:***		
		$P>Chi^2 = 0.1797$			*$P>Chi^2 < 0.0001$*			*$P>Chi^2 = 0.2464$*		
		DF = 507, Chi-Square = 536.06			*DF = 510, Chi-Square = 638.40*			*DF = 460, Chi-Square = 480.43*		

(Continued)

Table 5.11 - Coefficients Estimates for Heifer Hedonic Pricing Models, 2004 to 2009 - Continued

Characteristic	Variable description	2007			2008			2009		
		Observ. (lots)	Coefficient ($/cwt.)	P-Value (P>|t|)	Observ. (lots)	Coefficient ($/cwt.)	P-Value (P>|t|)	Observ. (lots)	Coefficient ($/cwt.)	P-Value (P>|t|)
Intercept	Intercept	1504	185.1295	< 0.0001	1505	140.8800	< 0.0001	1514	175.7114	< 0.0001
Lot size	Number of head	1504	0.0060	0.2817	1505	0.0043	0.4653	1514	0.0174	< 0.0001
(Lot size)^2	Number of head squared	1504	0.00001	0.3444	1505	-0.000002	0.8305	1514	-0.00002	0.0017
Weight	Average base weight of lot	1504	-0.3895	< 0.0001	1505	-0.2686	< 0.0001	1514	-0.3738	< 0.0001
(Weight)^2	Average base weight of lot squared	1504	0.00029	< 0.0001	1505	0.00021	< 0.0001	1514	0.00029	< 0.0001
Frame	Small to medium	686	-0.8041	0.002	670	-0.2493	0.3804	682	-0.2337	0.3237
	Medium to medium-large mix	653	Base		658	Base		632	Base	
	Medium-large to large	165	-0.2853	0.4708	177	-0.5468	0.1764	200	0.1300	0.6595
Flesh	Light to light-medium	63	-0.3489	0.5614	67	0.5114	0.4022	71	0.4278	0.4212
	Light-medium to medium mix	95	-0.0668	0.8947	127	-0.2079	0.7144	112	-0.1072	0.8045
	Medium	1314	Base		1275	Base		1291	Base	
	Medium to medium-heavy mix to heavy	32	-1.6729	0.0401	36	0.5238	0.5321	40	-0.3474	0.6022
Weight variation	Even to fairly even	76	2.1458	< 0.0001	89	1.4697	0.029	85	1.7005	0.0021
(uniformity)	Uneven	1360	Base		1351	Base		1366	Base	
	Very uneven	68	-0.0416	0.9419	65	0.5727	0.4619	63	1.1063	0.1132
Implant	Not implanted	611	Base		618	Base		629	Base	
	Natural eligible - Not implanted	530	0.3441	0.2069	510	0.9966	0.0009	522	0.2569	0.2978
	NHTC eligible - Not implanted				29	1.9656	0.0488	48	0.7835	0.2507
	Unknown or some implanted	60	-1.2124	0.0493	69	-0.4551	0.441	74	-1.2610	0.0071
	Implanted	303	-0.0260	0.939	299	0.2060	0.5208	268	0.2386	0.4012
Vaccination	Not vaccinated	63	Base		42	Base		16	Base	
	VAC 24	149	3.3585	< 0.0001	163	1.3416	0.1936	164	0.0882	0.956
	VAC 34	744	4.6314	< 0.0001	528	2.4658	0.0093	481	1.6480	0.2942
	VAC 34+				196	2.2400	0.0209	269	2.3106	0.1449
	VAC 45	381	7.2684	< 0.0001	323	6.5193	< 0.0001	367	5.2462	0.0009
	VAC Precon	38	8.7301	< 0.0001	14	3.7852	0.0321	18	4.4493	0.011
	One respiratory vaccination	103	2.0700	0.0055	108	1.1319	0.3064	79	-1.1169	0.5087
	Two or more respiratory vaccinations	26	3.7128	0.0005	131	1.7050	0.1664	120	0.3540	0.8393
	Weaning w/ respiratory vaccination				151	4.1301	< 0.0001	139	4.6514	< 0.0001
Pinkeye vaccinated	Not vaccinated or unknown				1420	Base		1448	Base	
	Vaccinated				85	0.4247	0.3619	66	1.4431	0.0128
***H. somni* vaccinated**	Not vaccinated or unknown				1169	Base		1187	Base	
	Vaccinated at least once				336	-0.0525	0.8702	327	0.2719	0.298
BVD PI-Negative	No				1437	Base		1463	Base	
	Yes				68	0.1509	0.8174	51	0.8762	0.2021
Bangs vaccinated	Not vaccinated or unknown				1238	Base		1222	Base	
	Vaccinated				267	-0.5956	0.1287	292	-0.2316	0.5246
Age-and-source vaccinated	No	1261	Base		1052	Base		842	Base	
	Yes	243	1.3892	< 0.0001	453	2.4773	< 0.0001	672	1.3944	< 0.0001
Horns	No horns	1426	Base		1416	Base		1419	Base	
	Some, tipped and all horns	78	-0.8092	0.1736	89	-1.1587	0.0652	95	-0.4573	0.3442
Breed	Cattle w/ ear	260	Base		251	Base		249	Base	
	English & English cross	161	3.9563	< 0.0001	155	5.6075	< 0.0001	132	4.5820	< 0.0001
	Continental & Continental cross	28	3.9533	< 0.0001	43	3.7676	< 0.0001	46	1.6421	0.0132
	English/Continental cross	557	3.0435	< 0.0001	538	4.7111	< 0.0001	537	2.7542	< 0.0001
	Black & black-white-faced	417	4.5334	< 0.0001	428	6.4360	< 0.0001	470	4.1497	< 0.0001
	Predominantly Angus	81	5.5588	< 0.0001	90	6.3423	< 0.0001	80	5.1382	< 0.0001
Price variation	Feeder cattle futures price	1504	0.4348	< 0.0001	1505	0.3928	< 0.0001	1514	0.3154	0.0001
Region of origin	West	327	-3.0056	< 0.0001	397	-3.9189	< 0.0001	423	-1.5961	0.0006
	Rocky Mountain/North Central	767	1.5154	0.0001	693	0.4547	0.3989	679	1.7689	< 0.0001
	South Central	306	Base		319	Base		316	Base	
	Southeast	104	-7.3867	< 0.0001	96	-10.3326	< 0.0001	96	-6.2242	< 0.0001
Days to delivery	Days between sale and delivery date	1504	-0.0172	< 0.0001	1505	-0.0212	< 0.0001	1514	-0.0158	< 0.0001
Analysis of Variance and Homoskedasticity		***Adj. R^2 Value:*** *0.7101*			***Adj. R^2 Value:*** *0.5850*			***Adj. R^2 Value:*** *0.6441*		
		Root MSE: *4.45330*			***Root MSE:*** *4.90952*			***Root MSE:*** *4.06509*		
		White Test Results:			***White Test Results:***			***White Test Results:***		
		$P>Chi^2 = 0.1155$			$P>Chi^2 < 0.0001$			$P>Chi^2 < 0.0023$		
		DF = 464, Chi-Square = 500.75			*DF = 690, Chi-Square = 919.86*			*DF = 680, Chi-Square = 789.05*		

5.2.1 Price Effect of Lot Characteristics

Region of origin was the only lot characteristic estimated in the 2004 to 2009 hedonic models. Price differentials for region were comparable for both steers and heifers. Similar to the 2008 to 2009 multi-year model, West- and Southeast-region calves were consistently discounted compared to South Central calves. Discounts for Western calves appeared similar for steers and heifers across model years and ranged from $1.29 to $5.57 per cwt. Calves from the Southeast received discounts from $2.17 to $10.61 per cwt. Steers and heifers from the North Central region were generally sold at a premium to South Central calves ($0.75 to $2.46 per cwt.), but in 2005 prices for steers and heifers in these regions were not statistically different and again in 2008 heifers were priced similarly across these two regions.

5.2.2 Price Effect of Genetic Characteristics

Calves considered small to medium framed continued to receive discounts on SLA video markets. Statistically significant discounts ranging from $0.56 to $0.76 per cwt existed for small to medium framed steers, and statistically significant price differences were not found in 2006 and 2009. Smaller heifers were discounted more severely than steers with discounts of $0.62 to $0.80 per cwt., but statistically significant discounts for heifer frame size did not exist in 2008 and 2009. Furthermore, statistically significant price differences did not exist for medium-large to large framed calves compared to medium to medium-large mixed frame lots from 2004 to 2009. In general, cow-calf producers can expect to be discounted $0.56 to $0.80 per cwt. for smaller-framed calves, but larger-sized cattle are not statistically different than medium-framed calves.

Steer and heifer calves with horns received discounts in 2004 and 2005 ranging from $0.21 to $1.09 per cwt. Total horned observations decreased 75 percent following the 2006 data collection changes, and the price effect for horns was more variable in proceeding models. In the eight separate models from 2006 to 2009, only two produced statistically significant price differentials for horned calves, and the estimate for 2006 horned steers came back as a premium of $1.18 per cwt. Schultz et al. (2010), Sartwelle et al. (1996a) and Lambert et al. (1989) show discounts for horned calves ranging from $0.60 to $2.20 per cwt. In addition to data collection changes, it is likely cow-calf producers are making conscious breeding and management decisions to reduce the number of horned calves on their ranches. The National Beef Quality Audit has stressed quality concerns of horned animals to later beef sectors, and it is likely that producers are reacting to this information and the price signals they have received through auction market (Garcia et al. 2008 and Boleman et al. 1998). Horned calves present less management nuisances as they become less prominent in video market sale lots, and feeder calf buyers are less likely to discriminate based on the presence of only a few horned calves since a smaller number of horns means overall less meat quality issues.

Variables for aggregate breed influence needed to be adjusted compared to the 2008 to 2009 analysis. Red Angus calves were not identified separately from English and English-cross calves in earlier model years. These observations were combined with English and English-cross calves for all model years. Also, Continental and Continental-cross calves did not reach two percent of observations in at least one gender in most model years. It was decided that these calves were physiologically different from the other aggregated breed variables and thus needed to remain in the analysis as an independent variable despite the low number of observations.

Breed continued to have a considerable influence on feeder calf prices in SLA video markets. The relative magnitude of each breed effect remained unchanged from 2004 to 2009. The breed premiums relative to Brahman-influenced calves are summarized in Figure 5.7 and Figure 5.8. Premiums for Angus and black and black-white faced calves were consistently among the highest premiums ranging from \$4.15 to \$8.20 per cwt., while Continental-influenced calves generated the smallest premium relative to Brahman calves with an additional \$1.20 to \$5.05 per cwt. Premiums between Angus and black and black-white faced heifers were statistically different from each other for four of the six years and different only three of the six years for steers (Table 5.12). In general, breed-influence price differentials for heifers showed more variability among coefficient estimates than steers, which likely contributed to the test results. The F-test also showed that coefficient estimates among all breeds, regardless of gender, are statistically different.

Table 5.12 - Breed Influence F-test Results, 2004 to 2009

F-test description	Year	Null Hypothesis	Steers		Heifers	
			P-value	Test result	P-value	Test result
All breeds are equal	2004	(15)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2005	(15)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2006	(15)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2008	(15)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2009	(15)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2007	(15)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
Angus = black-hide color	2004	(16)	0.8941	Fail to reject H_0	< 0.0001	Reject H_0
	2005	(16)	0.0002	Reject H_0	< 0.0001	Reject H_0
	2006	(16)	0.7281	Fail to reject H_0	0.3776	Fail to reject H_0
	2007	(16)	0.0356	Reject H_0	0.0615	Fail to reject H_0
	2008	(16)	0.3522	Fail to reject H_0	0.8786	Fail to reject H_0
	2009	(16)	0.0025	Reject H_0	0.0528	Fail to reject H_0

Figure 5.7 - Effect of Breed Influence on Steer Prices, 2004 to 2009

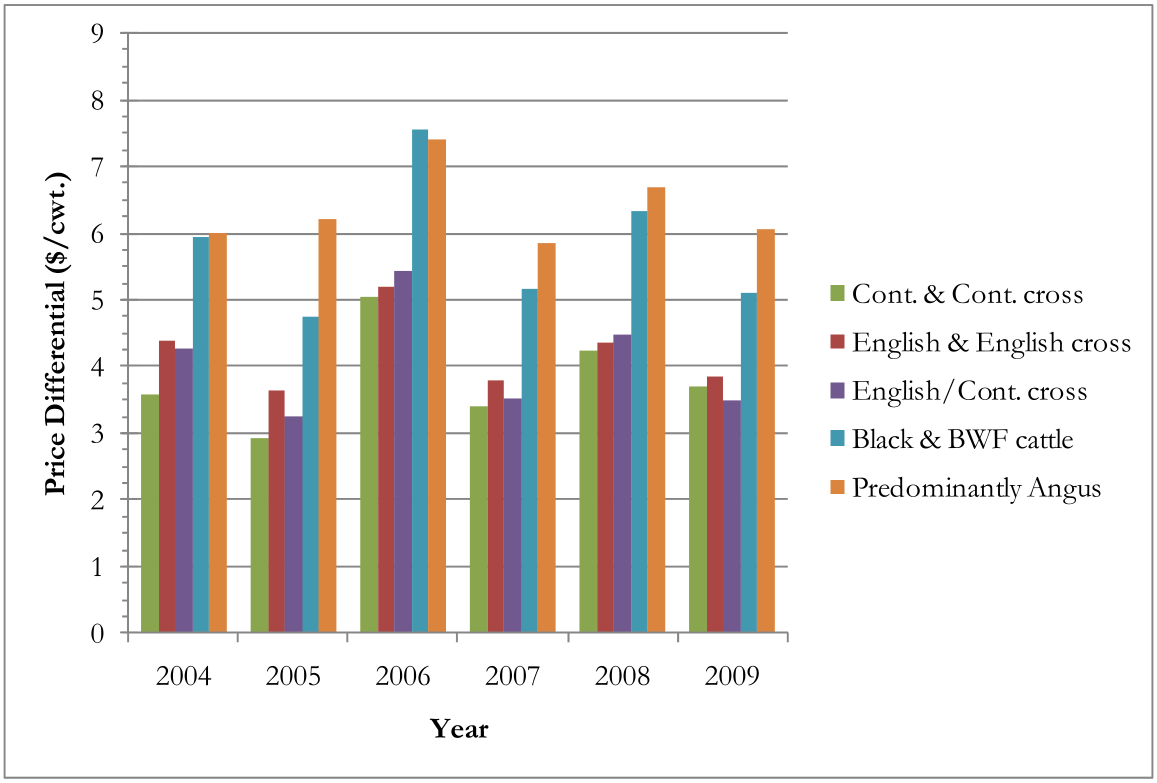
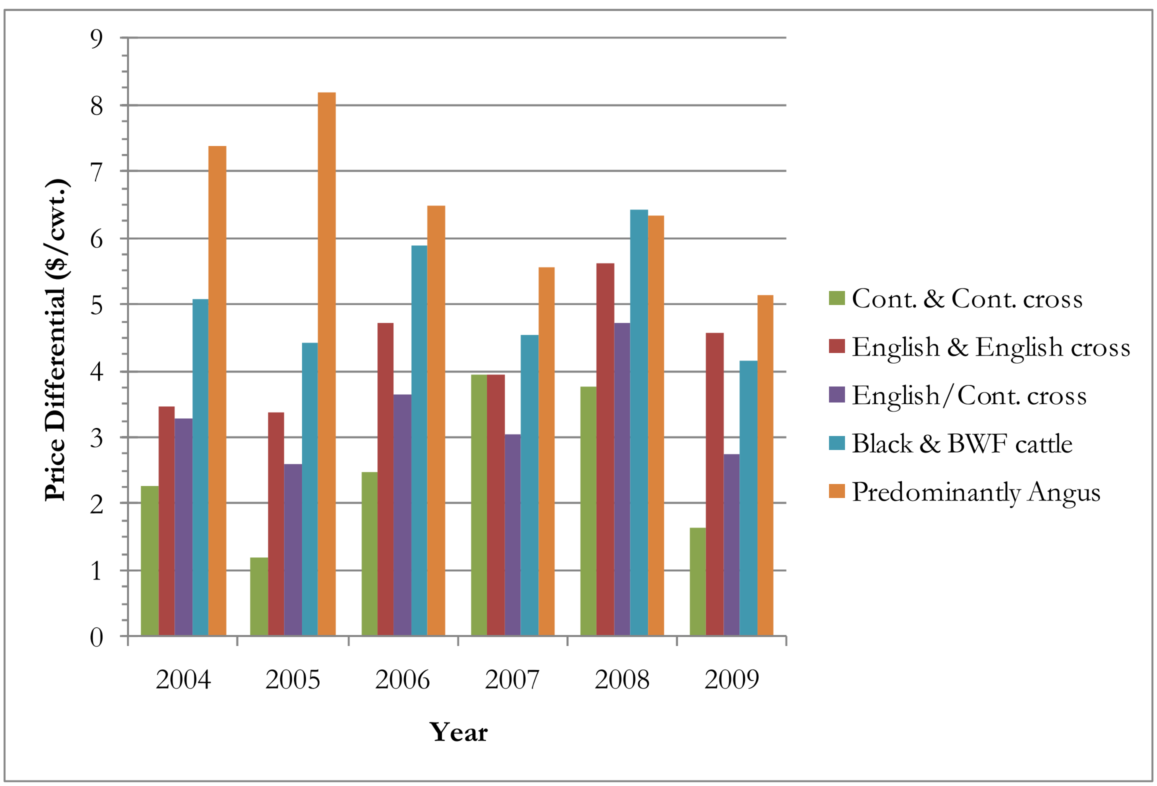


Figure 5.8 - Effect of Breed Influence on Heifer Prices, 2004 to 2009



The number of Angus and black and black-white faced sale lots in SLA video markets increased steadily from 2004 to 2009 at the expense of Brahman-influenced and English-Continental cross calves (Figure 5.9 and Figure 5.10). Some variation from 2005 and 2006 can be attributed to data collection changes. However, it does not diminish the trend that cow-calf producers were transitioning from non-black English-Continental and Brahman-influenced cowherds to Angus and black-hided breeding programs over the last six years.

Figure 5.9 - Distribution of Breeds in Steer Calves, 2004 to 2009

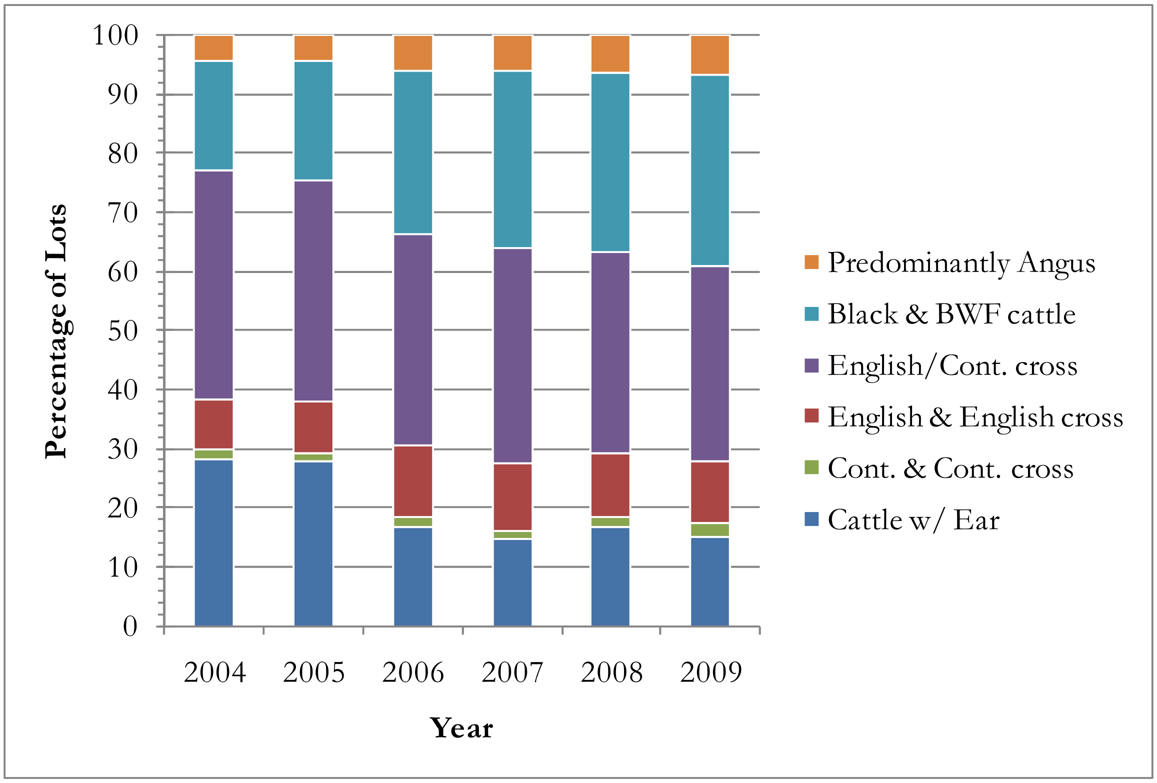
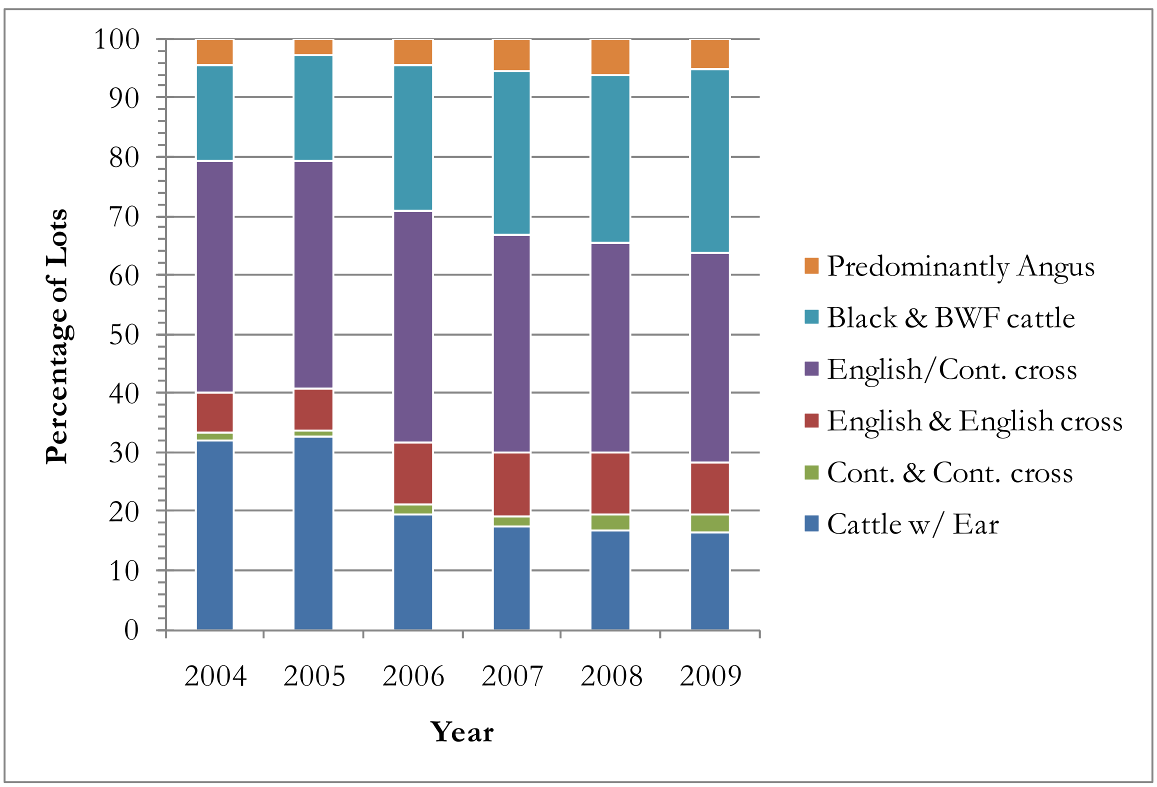


Figure 5.10 - Distribution of Breeds in Heifer Calves, 2004 to 2009



5.2.3 Price Effect of Management Characteristics

The statistical significance of flesh score as a price determinant in feeder calves varied considerably from year to year. Light-medium to medium mix flesh score steers earned an additional $0.90 to $2.25 per cwt. compared to medium fleshed steers from 2004 to 2009. Discounts of $1.36 to $1.78 per cwt. were given to medium to medium-heavy mix and heavy fleshed lots of steers from 2005 to 2007. Heifers considered light to light-medium in flesh score received premiums around $1.85 per cwt. in 2004 and 2005. The market advantages for light-medium to medium flesh heifers were smaller in 2005 and 2006 and ranged from $1.18 to $1.44 per cwt. Discounts $1.67 and $1.78 per cwt. were given to heavier fleshed heifers in 2005 and 2007. The results are scattered considerably across year and gender, but the price determinants indicate that heavier condition is negatively correlated with feeder calf prices. Lighter fleshed calves have the potential to receive premiums as high as $2.25 per cwt., and over-conditioned animals could be marked down as much as $1.75 per cwt.

A non-linear price-weight relationship existed in steer and heifer sales throughout the six model years. The largest weight-related discounts in SLA video markets occurred in 2005 and 2006, while 2008 and 2009 represented the two years with the smallest discounts (Figure 5.11 and Figure 5.12). Cow-calf producers can expect 700 lbs. calves to receive discounts ranging from around $12 to $30 per cwt. compared to 450 lbs. calves. Uniform sale lots consistently generated a premium over lots with uneven and very uneven weight variation. In general, even to fairly even heifer lots were rewarded more than steers and received premiums of $1.47 to $2.71 per cwt. Steers with even to fairly even lot uniformity generated premiums of $0.82 to $1.42 per cwt., but these premiums did not exist in 2008 and 2009. There were statistically significant discounts for calves with very uneven weight variation ranging from $1.06 to $1.59 per cwt. for model years 2004 and 2005. Uniformity presents a stronger opportunity for premiums in heifer lots where premiums are around $1.50 to $2.75 per cwt. Steer premiums for uniformity are not as robust, but the potential exist for $1.50 premiums. In general, producers should avoid extreme weight variation in SLA video market sales.

Trends in weaning and vaccination protocol are more difficult to assess based on the known database changes that occurred from 2006 to 2007. Figure 5.13 and Figure 5.14 capture the distribution of vaccination protocol from 2004 to 2009. It appears the population of VAC 34 and VAC 34+ calves has increased at the expense of non-certified vaccination programs. However, these trends could easily be a product of database changes rather than actual production adjustments among cow-calf producers selling on SLA video markets.

Figure 5.11 - Steer Price-Weight Relationship, 2004 to 2009

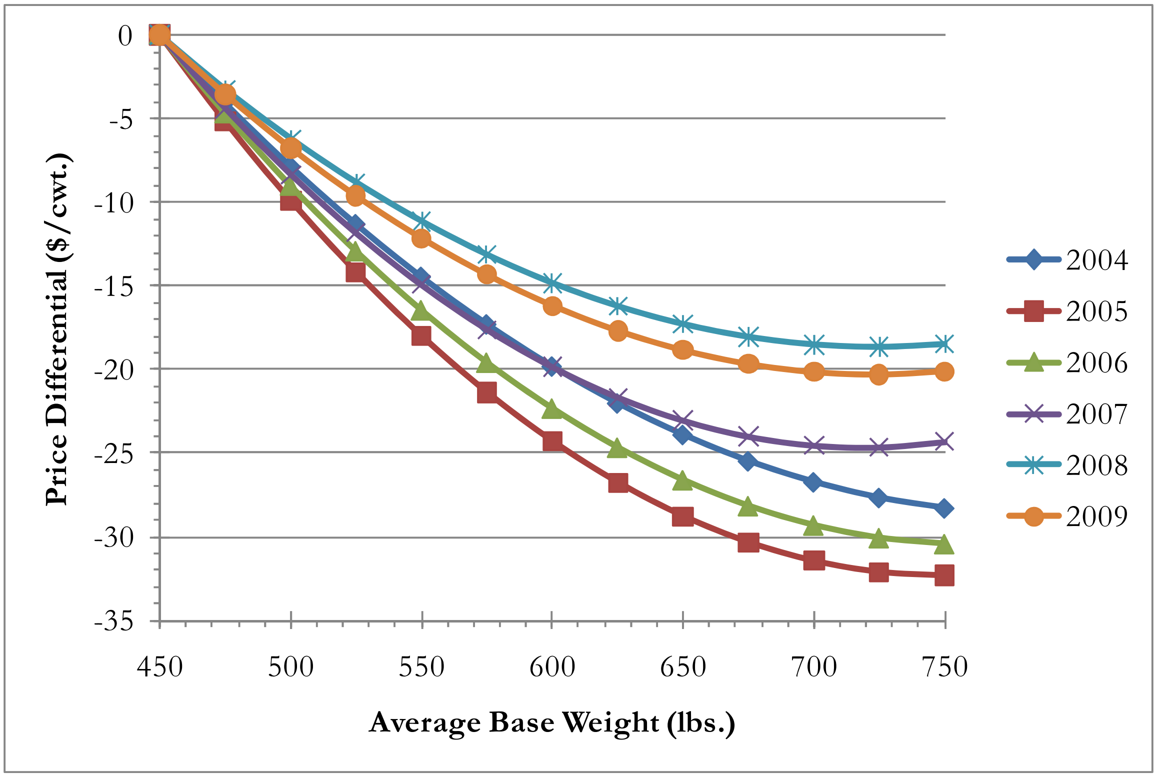
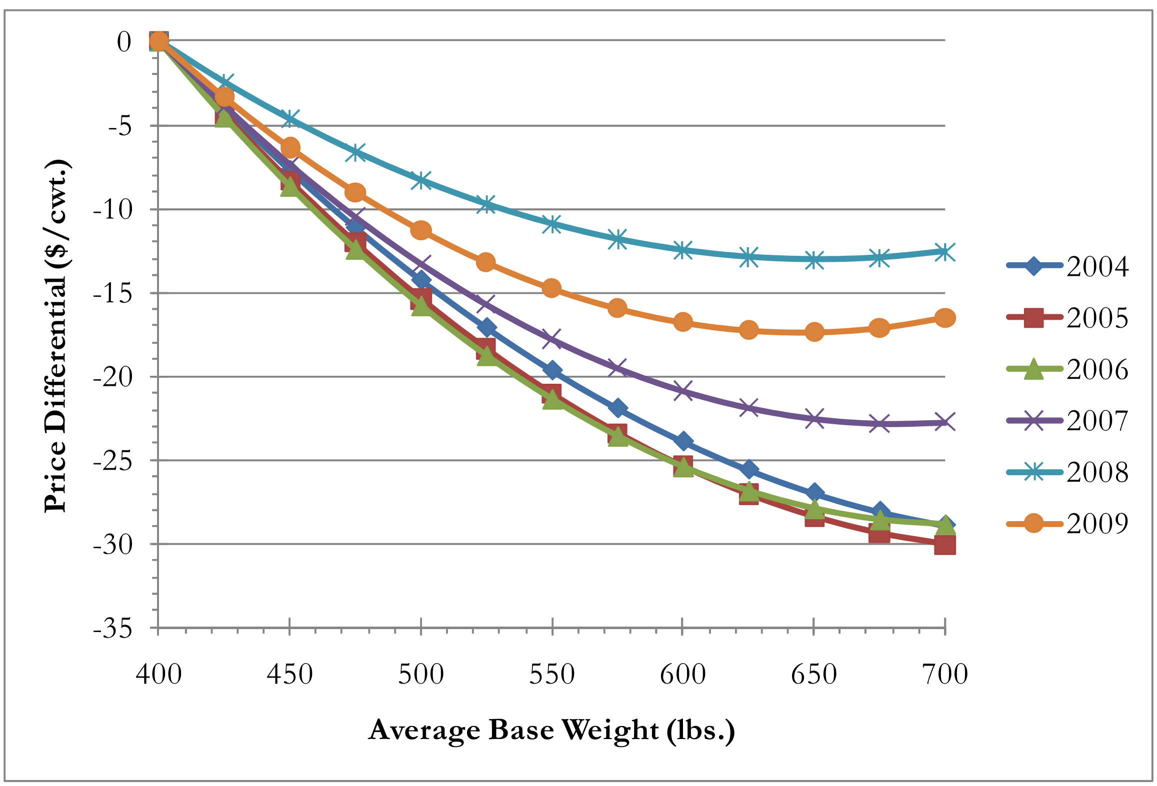


Figure 5.12 - Heifer Price-Weight Relationship, 2004 to 2009



Premiums for weaning and vaccination protocols were generally higher for steers compared to heifers from 2004 to 2009 (Figure 5.15 and Figure 5.16). The premiums for VAC 24 calves compared to non-weaned and non-vaccinated calves were consistently among the lowest of the certified health programs. Statistically significant premiums for VAC 24 steers ranged from $1.71 to $2.85 per cwt. Steers managed with VAC 34 protocols received premiums from $2.72 to $ $4.15 per cwt., and VAC 34+ steers received similar prices. The price differential for VAC 45 steers ranged from $6.03 to $7.90 per cwt., and VAC Precon generated premiums of $5.80 to $10.72 per cwt. Premiums for steers in non-certified health programs receiving a single vaccination were not statistically significant in three study years, but the potential existed for an additional $2.14 per cwt. Premiums for steers that received multiple respiratory vaccinations from a non-certified health program were not statistically significant in 2009. In the remaining years, the premiums for this variable ranged from $2.15 to $2.98 per cwt. Weaned steers vaccinated under a non-certified health program received an additional $2.71 to $5.10 per cwt.

Premiums for weaned and vaccinated heifers were generally more variable than steers (Figure 5.17 and Figure 5.18). The premium for VAC 24 heifers was statistically significant in 2004, 2005 and 2007 and ranged from $1.85 to $3.86 per cwt. Heifers meeting VAC 34 and VAC 34+ protocol earned $1.91 to $4.63 per cwt. more than non-vaccinated and non-weaned heifers, but the price differential for VAC 34 was not statistically significant in 2009. There was a statistically significant premium for VAC 45 heifers throughout the analysis that ranged from $2.38 to $8.73 per cwt. The premiums for VAC Precon heifers were considerably lower than the premiums seen in the steer models. The VAC Precon premium was the lowest in 2004 at $2.38 per cwt., and reached a high of $8.73 per cwt. in 2007 but was around $4.25 to $4.50 per cwt. for the remaining years. The price differential for heifers with one non-certified respiratory vaccination was statistically significant in 2005 and 2007. These heifers received a premium of $1.26 and $2.07 per cwt. Heifers vaccinated multiple times for respiratory diseases in a non-certified health program received statistically significant premiums in 2005 and 2007 and earned $1.71 to $3.71 per cwt. more than non-vaccinated and non-weaned heifers. Weaning commanded an additional $2.90 to $4.65 per cwt. for heifers in non-certified health programs across all years.

Figure 5.13 - Distribution of Steer Vaccination and Weaning Protocol, 2004 to 2009

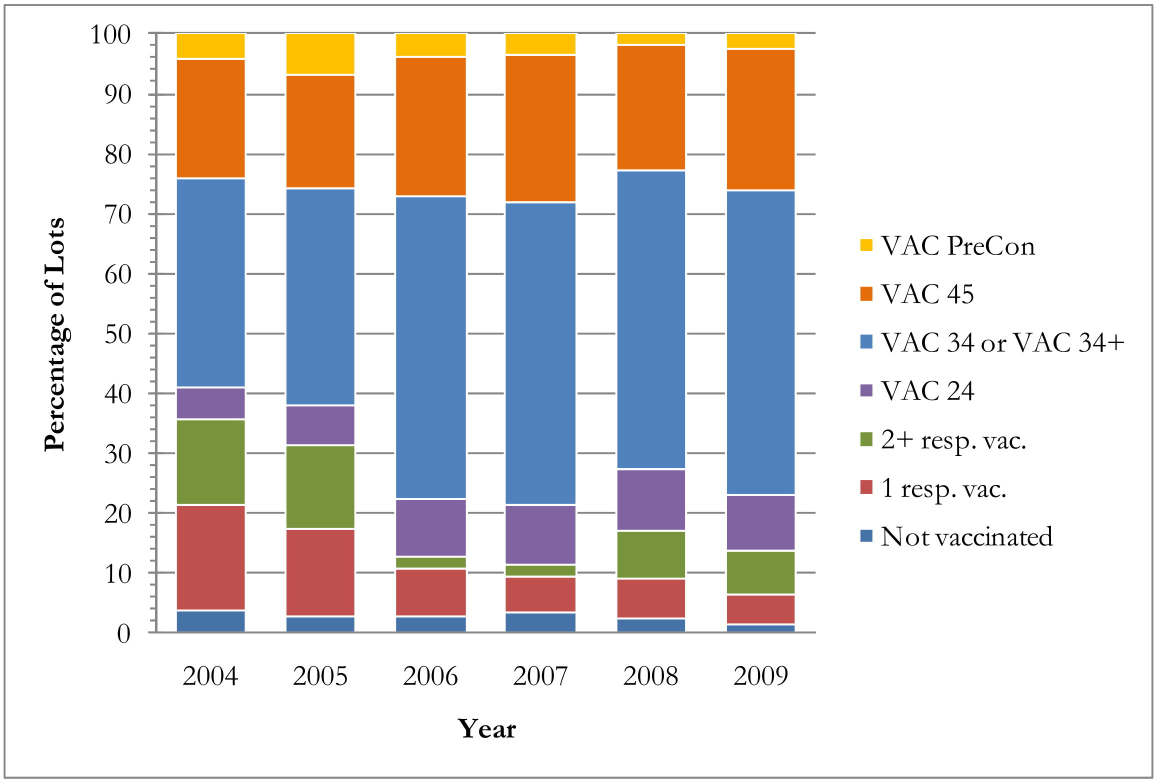


Figure 5.14 - Distribution of Heifer Vaccination and Weaning Protocol, 2004 to 2009

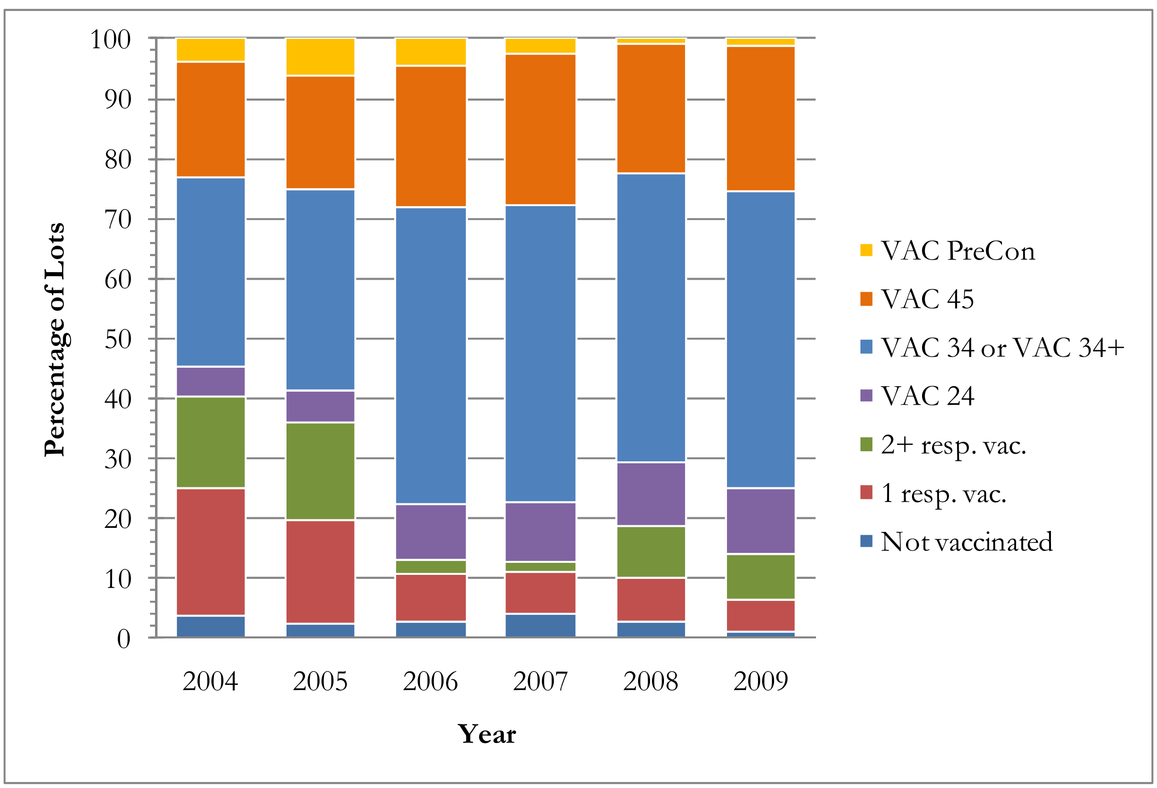


Figure 5.15 - Non-Weaned Steer Vaccination Price Differentials, 2004 to 2009

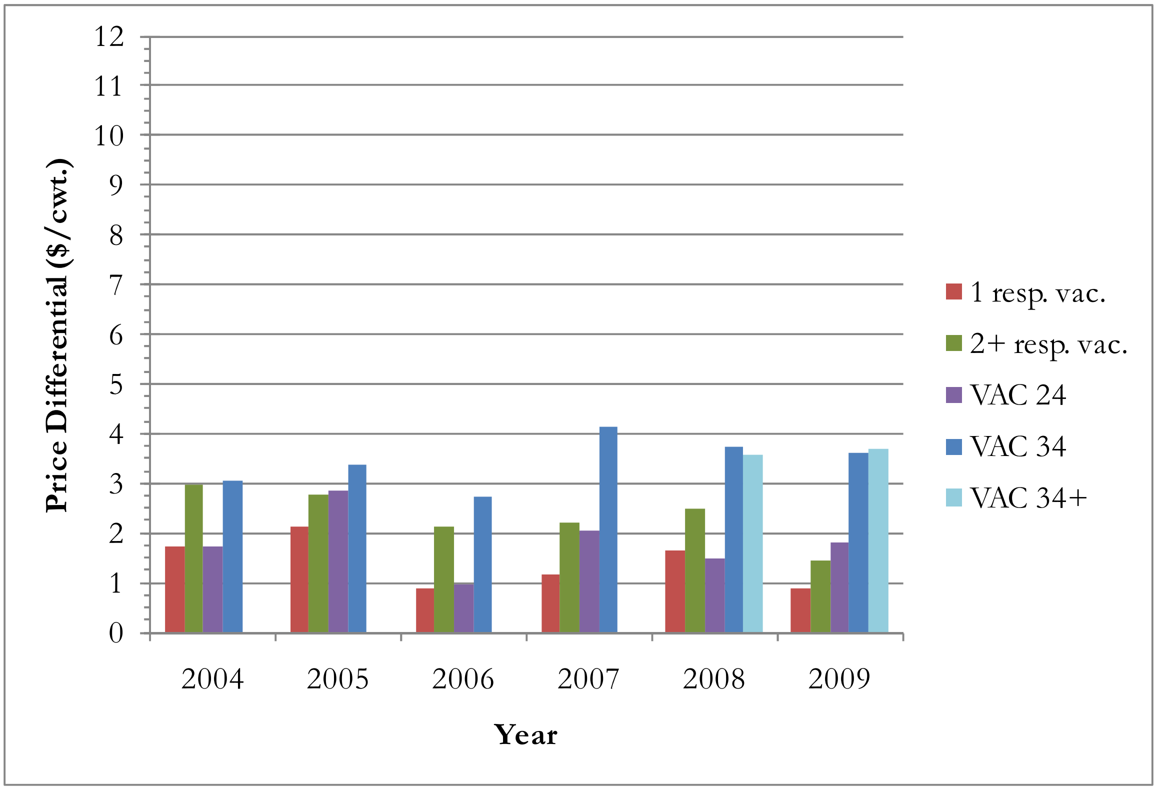


Figure 5.16 - Weaned Steer Vaccination Price Differentials, 2004 to 2009

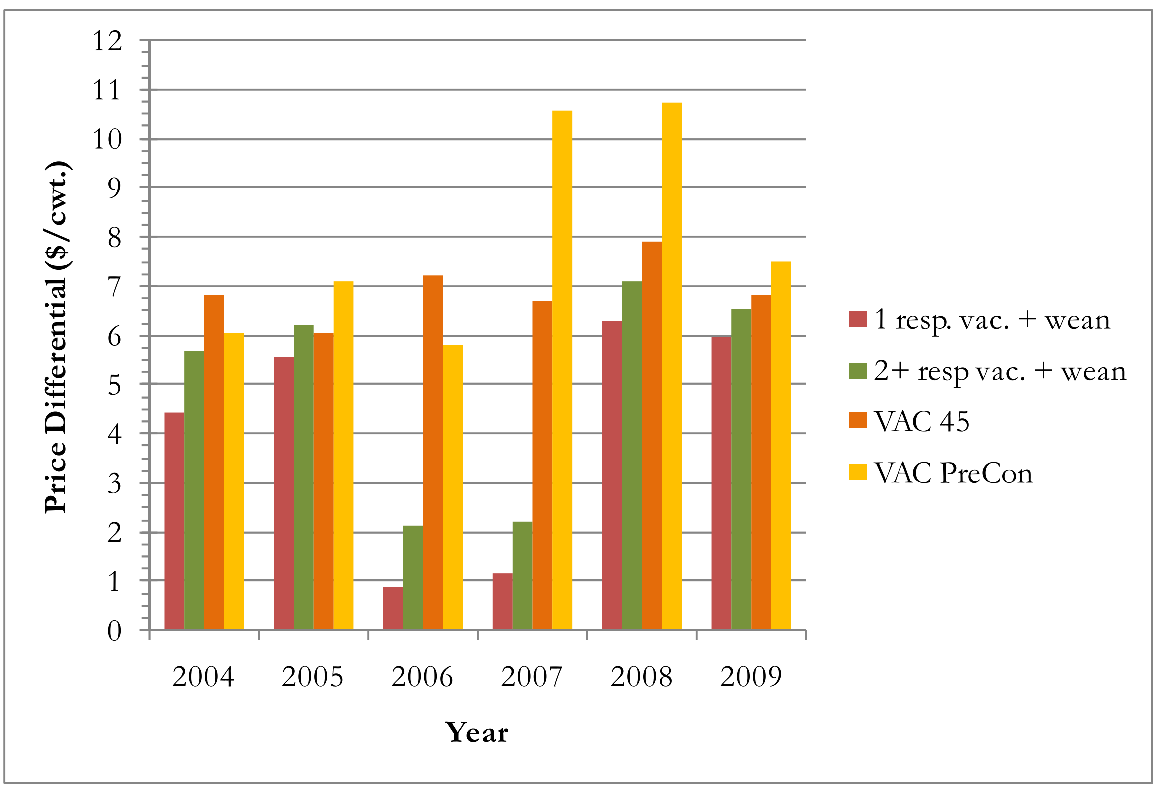


Figure 5.17 - Non-Weaned Heifer Vaccination Price Differentials, 2004 to 2009

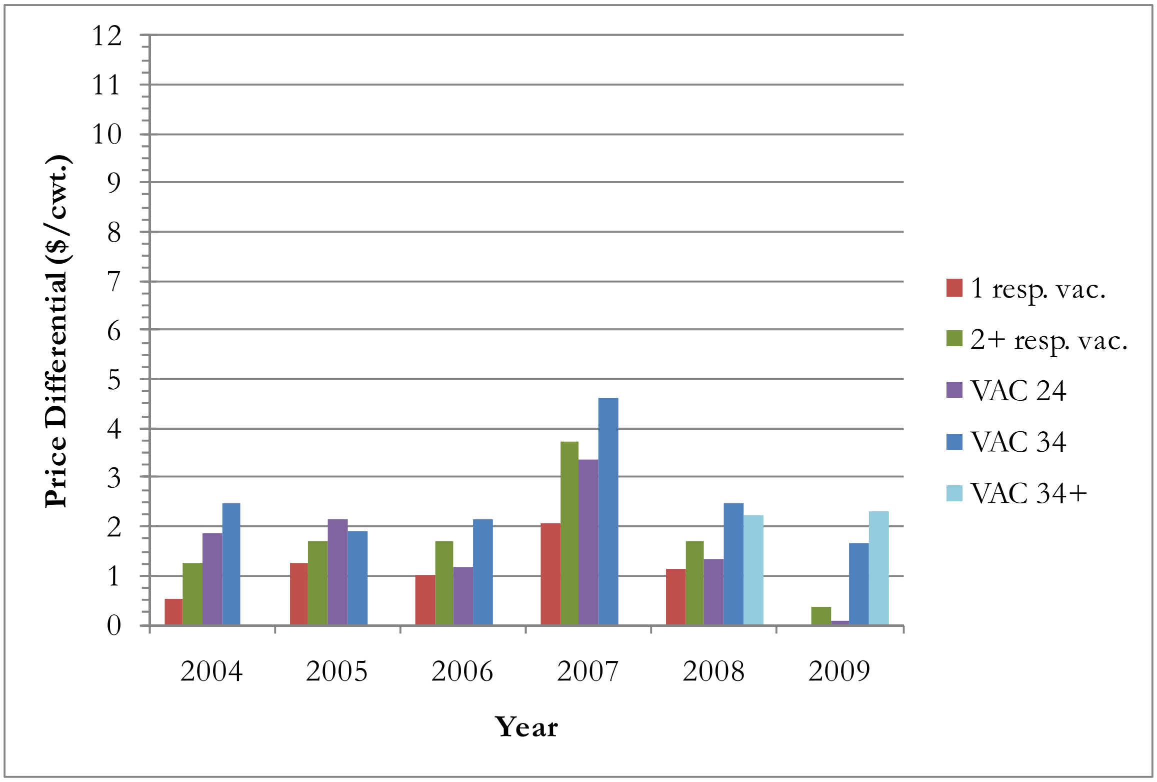
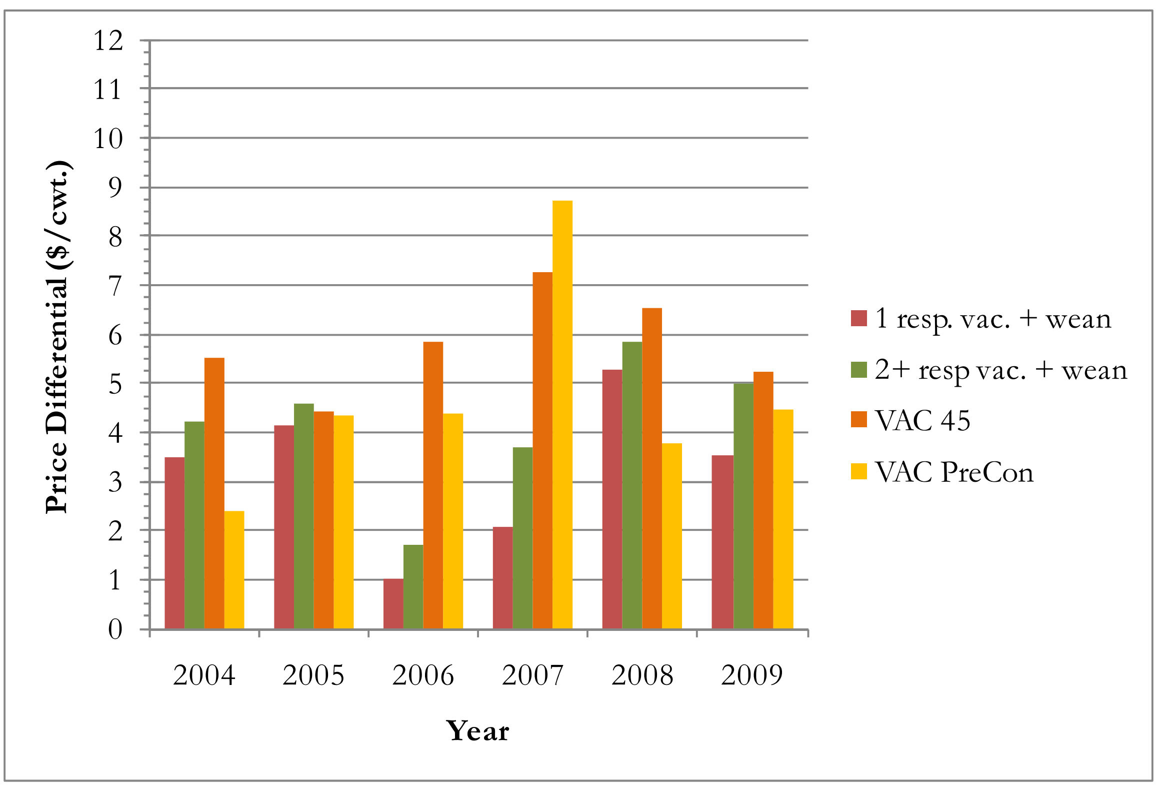


Figure 5.18 - Weaned Heifer Price Differentials, 2004 to 2009



Similar to breed influence, weaning and vaccination programs represent one of the largest revenue enhancing management practices available to cow-calf producers selling calves on the SLA video market. Non-weaned calves that are vaccinated against respiratory diseases can earn up to an additional $1.50 to $3.50 per cwt. on SLA video markets. Cow-calf producers willing to invest resources into a weaning and vaccination program can receive up to $5.50 to $7.50 per cwt. in sale premiums. If a producer chooses to use a non-certified health program, weaning can add an additional $2.75 to $4.50 per cwt. Premiums for weaning and respiratory vaccinations are highly dependent on health program requirements and can fluctuate considerably from year to year. Also, price differentials for lower-tiered health and vaccination programs are less consistent compared to more stringent certified health programs.

Table 5.13 shows the F-test results for the various vaccination and weaning protocols. Each vaccination protocol is considered statistically different from one another. However, pair-wise observations provide better insight into how the market differentiates value based on vaccination and weaning claims. Calves with VAC 24 certification were generally considered the same as calves with one respiratory vaccination, while the price differentials for VAC 34 calves were generally considered statistically different from calves with a single non-certified respiratory vaccination. Also, producers who weaned their calves and administered multiple respiratory vaccinations generally received the same market benefit as producers that followed VAC 45 protocol.

Vaccinations for pinkeye and *H. somni* as well as BVD-PI negative tested cattle were included in SLA video market lot descriptions in 2008. The price differential for BVD-PI negative calves was not statistically significant for steers or heifers in the 2008 and 2009 models. However, vaccinations for pinkeye and *H. somni* generated statistically significant price effects starting in 2009 despite being introduced in 2008 lot descriptions. Pinkeye vaccinations led to premiums of $1.55 and $1.44 per cwt. for steers and heifers, respectively, and *H. somni* vaccinations generated an additional $0.45 per cwt. for heifers.

Compared to non-implanted calves, the price determinants for implanted calves and sale lots with some implanted calves or calves with unknown implant history are generally weak over the six years analyzed. Implanted steers received a premium of $0.52 per cwt. in 2009. The 2009 premium represented the only statistically significant implant estimate in the annual models and was considered an anomaly. Buyers would typically not consider implanted calves at a premium to non-implanted calves. Statistically significant discounts for lots with unknown or mixed implant protocols appeared in four model years for steers and three years for heifers. The discounts ranged from $0.60 to $1.64 per cwt. for steers and $0.53 to $1.26 per cwt. for heifers. It is possible that these premiums represent a recent change in buyer preferences. As more attention has been given to the Beef Quality Assurance and carcass quality, it is possible that buyers are paying closer attention to the effect of previous management on later sectors and are discounting calves with unknown or mixed implant history.

Table 5.13 - Vaccination and Weaning Protocol F-test Results, 2004 to 2009

F-test description	Year	Null Hypothesis	Steers		Heifers	
			P-value	Test result	P-value	Test result
All vaccination protocols are equal	2004	(17)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2005	(17)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2006	(17)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2007	(17)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2008	(17)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2009	(17)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
VAC 24 = One vaccination	2004	(18)	0.9309	Fail to reject H_0	0.0156	Reject H_0
	2005	(18)	0.1049	Fail to reject H_0	0.1247	Fail to reject H_0
	2006	(18)	0.9079	Fail to reject H_0	0.826	Fail to reject H_0
	2007	(18)	0.0423	Reject H_0	0.0265	Reject H_0
	2008	(18)	0.7676	Fail to reject H_0	0.7963	Fail to reject H_0
	2009	(18)	0.0956	Fail to reject H_0	0.0849	Fail to reject H_0
VAC 34 = One vaccination	2004	(19)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2005	(19)	0.0002	Reject H_0	0.1211	Fail to reject H_0
	2006	(19)	< 0.0001	Reject H_0	0.0365	Reject H_0
	2007	(19)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2008	(19)	< 0.0001	Reject H_0	0.0537	Fail to reject H_0
	2009	(19)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
VAC 34+ = Multiple vaccinations	2008	(20)	0.1101	Fail to reject H_0	0.5509	Fail to reject H_0
	2009	(20)	0.0009	Reject H_0	0.0157	Reject H_0
VAC 45 = Multiple vaccinations and weaning	2004	(21)	0.0013	Reject H_0	0.0008	Reject H_0
	2005	(21)	0.6646	Fail to reject H_0	0.6638	Fail to reject H_0
	2008	(21)	0.0521	Fail to reject H_0	0.1844	Fail to reject H_0
	2009	(21)	0.5223	Fail to reject H_0	0.6154	Fail to reject H_0

5.2.4 Price Effect of Marketing Characteristics

Lot size continued to have a statistically significant non-linear relationship with the price of steers and heifers in SLA video market sales. As mentioned in Section 5.2, the non-linear relationship is not as strong as in previous research using local auction market data since the average lot size of 120 to 125 head is already considered large by traditional auction market standards. Figure 5.19 and Figure 5.20 illustrate the non-linear price-lot size relationship for steers and heifers, respectively. The coefficient estimate for the lot-squared variable was not statistically significant for steers in 2006, 2007 and 2008. Similarly, the non-linear price-lot size relationship was not statistically significant in the heifer models for 2007 and 2008.

The days-to-delivery variable was statistically significant in all steer and heifer models. In 2004 and 2005, the coefficient estimate for steers and heifers was positive and ranged anywhere between $0.01 and $0.03 per cwt. for each day until delivery. The results for these two years likely captured a price trend representing a period of particular market optimism for future profitability. Buyers might have been comfortable paying a slight premium for deferred delivery cattle. The remaining model years estimated that days to delivery had a statistically significant discount ranging from $0.01 to $0.03 per cwt. for each day between the sale and delivery date.

Figure 5.19 - Steer Price-Lot Size Relationship, 2004 to 2009

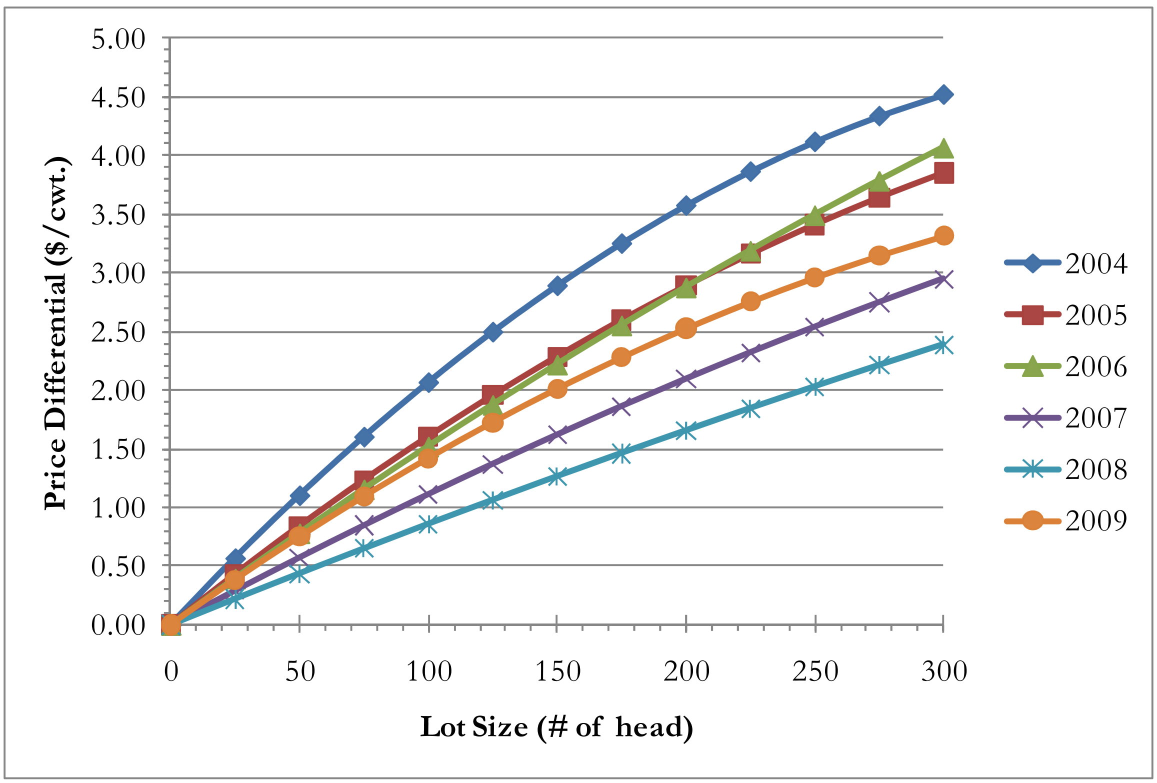
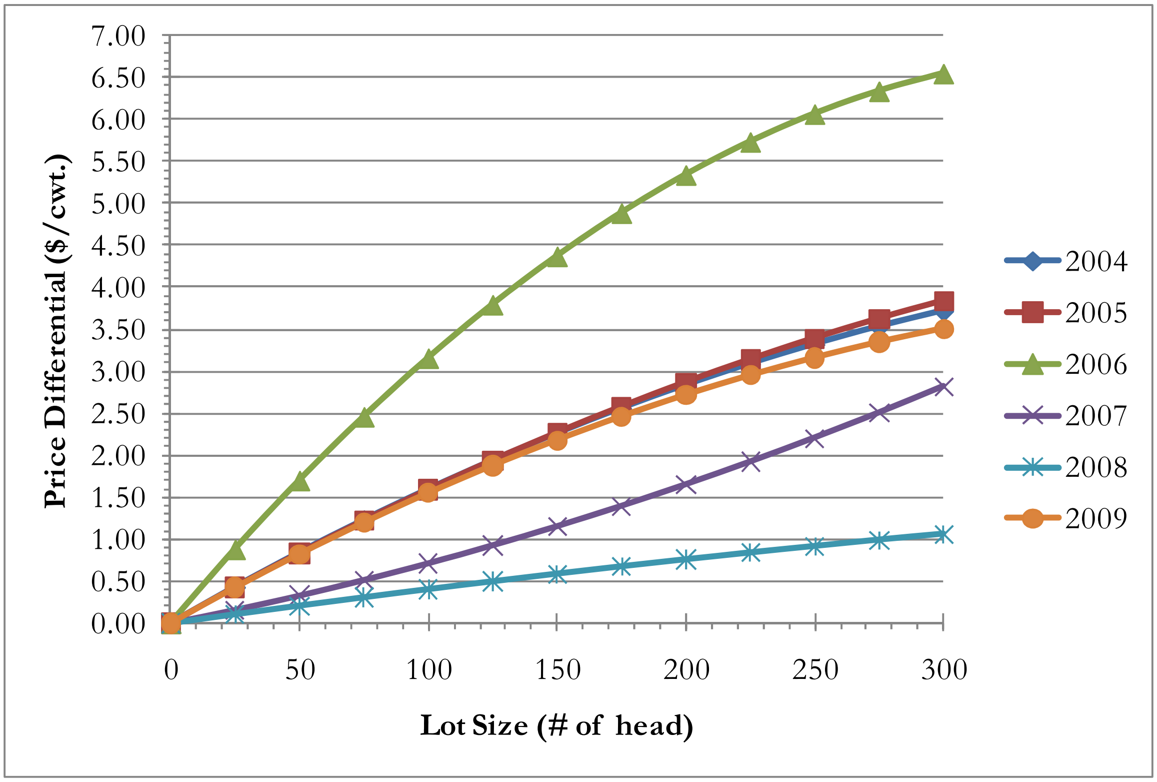


Figure 5.20 - Heifer Price-Lot Size Relationship, 2004 to 2009



Certified Natural Cattle were added to SLA video market lot descriptions in 2004 and NHTC-market eligible calves were added in 2008. These programs have each created new market opportunities for producers wanting to raise calves for these production systems. Statistically significant premiums in these programs have been sporadic during the six model years, while program participation appears to be increasing (Figure 5.21 and Figure 5.22). Premiums existed in SLA video market sales for natural-eligible steers and heifers in 2004, 2006 and 2008. The premiums were similar for each gender and ranged from $0.49 to $1.47 per cwt. A $2.70 per cwt. premium for NHTC-market eligible steers in 2008. Similarly, heifers received an additional $1.97 per cwt. in 2008. Premiums for NHTC were not significant in 2009. The result is not entirely unexpected since natural and NHTC production represent a relatively small proportion of the beef produced and exported in the United States. The fluctuating premiums for natural and NHTC calves suggest that demand for these programs is generated from a relatively small number of buyers. Until these markets generate stronger and more consistent price signals, cow-calf producers on the SLA video market should not depend on these premiums.

Figure 5.21 - Distribution of Implant, Natural and NHTC Programs in Steers, 2004 to 2009

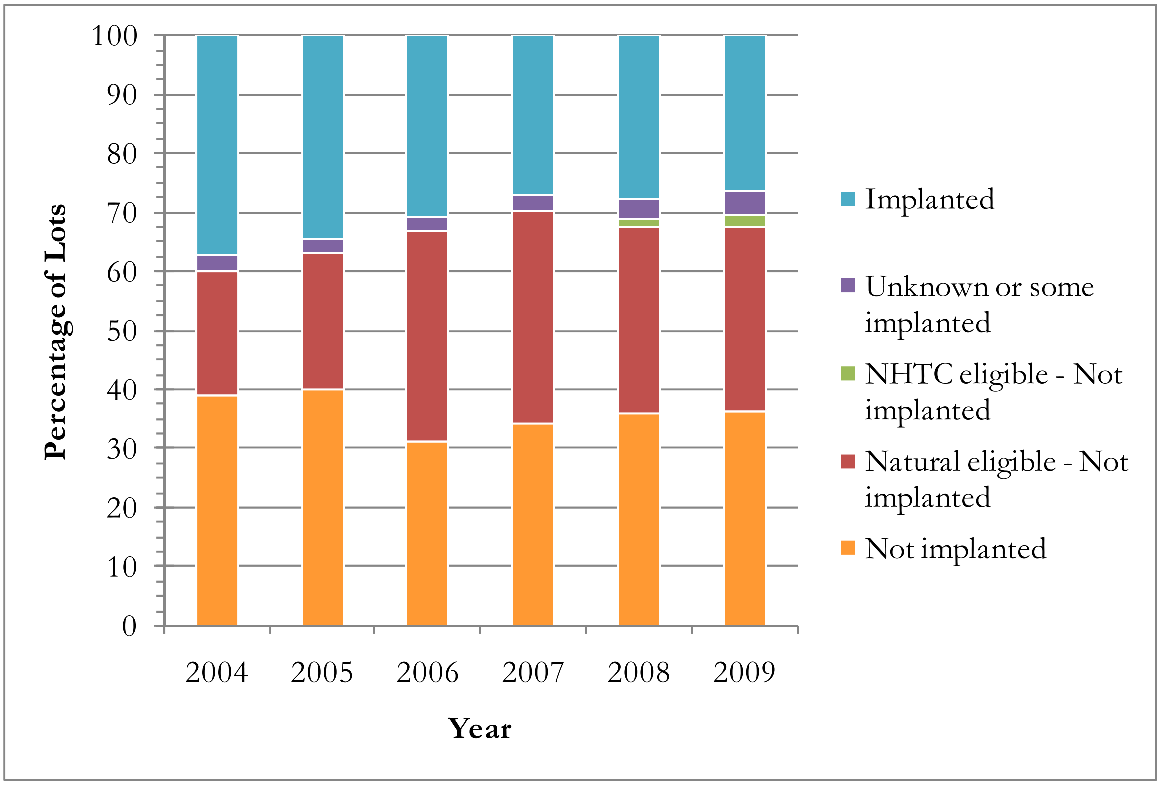
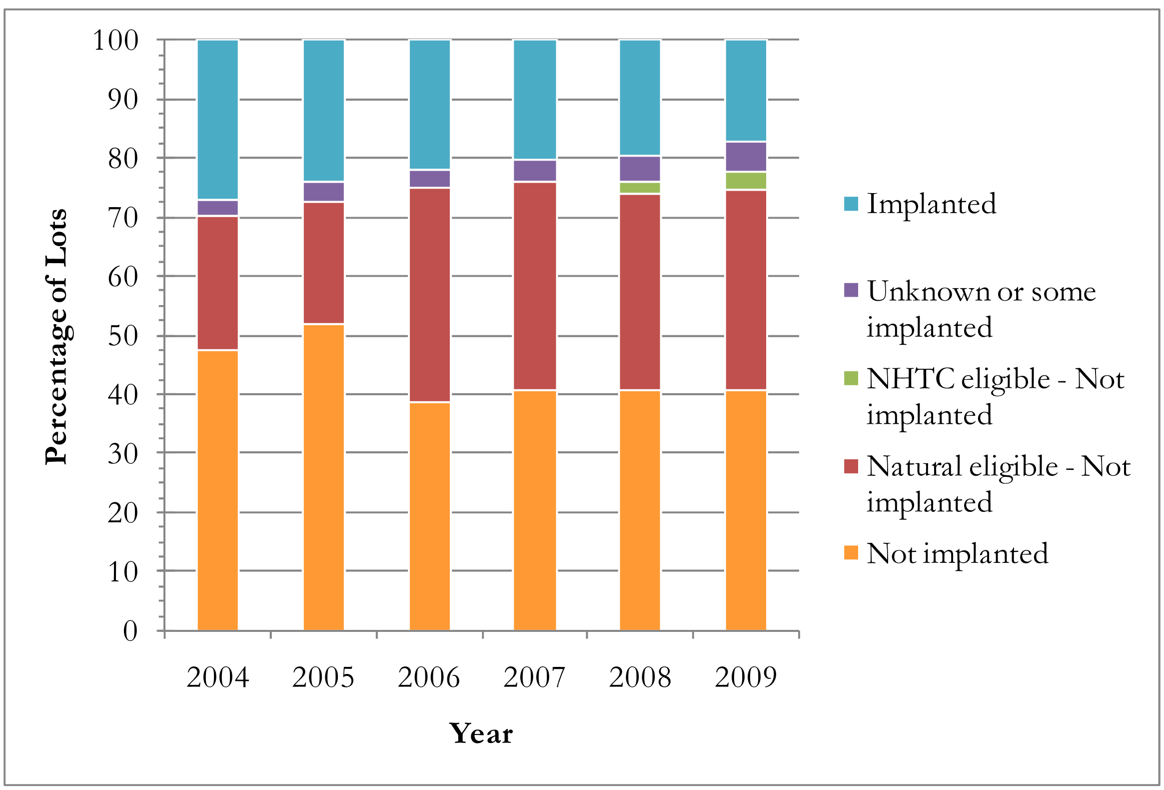


Figure 5.22 - Distribution of Implant, Natural and NHTC Programs in Heifers, 2004 to 2009



Age-and-source verification has been featured in SLA lot descriptions since 2005 and has consistently generated premiums for steers and heifers throughout that time. The premiums have been similar for steers and heifers throughout the analysis. The advantage for ASV calves started with $0.90 per cwt. premiums in 2005 and has been between $1.50 and $2.00 per cwt. since that time. These premiums have continued to hold as participation in ASV has steadily grown to include more than 45 percent of all calves sold in 2009 (Figure 5.23 and Figure 5.24). Premiums for ASV calves reached a high in 2008. The number of ASV lots increased 15 percent in 2009 and market premiums declined. It is too early to tell if the drop in premiums was associated with increased ASV participation, but it is certainly an opportunity for future research.

Figure 5.23 - Price Effect and Percentage of ASV Steer Lots, 2004 to 2009

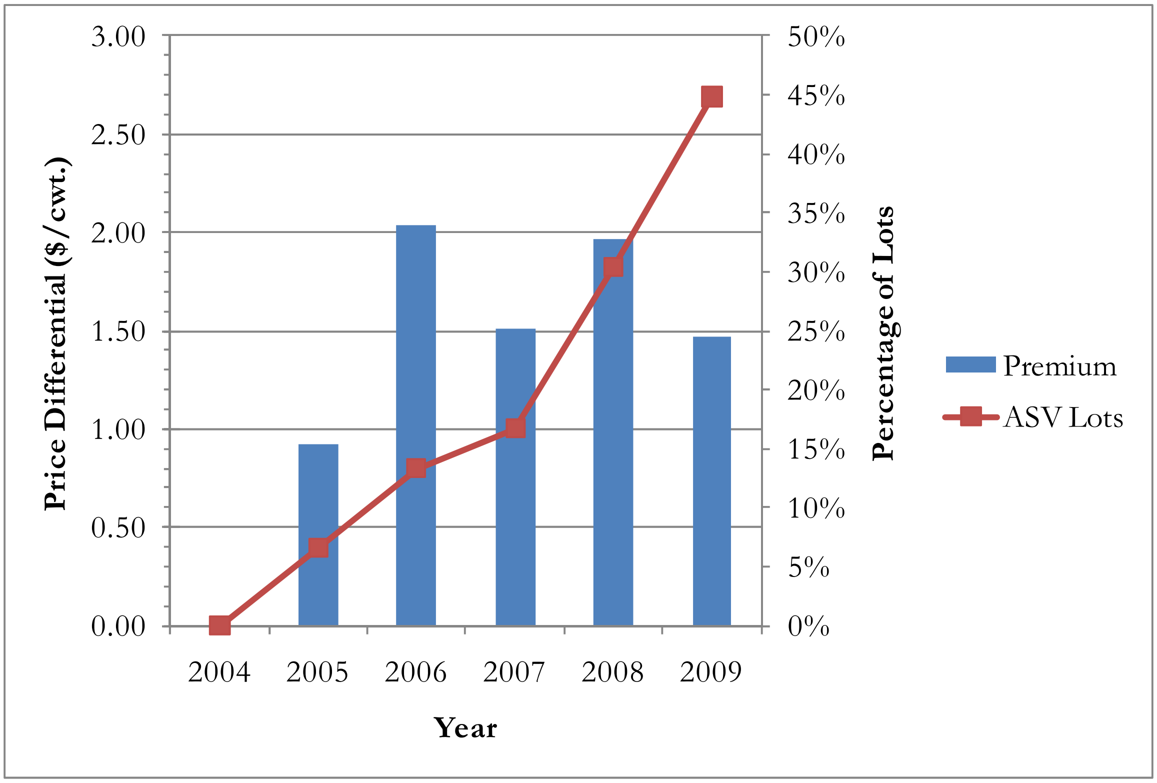
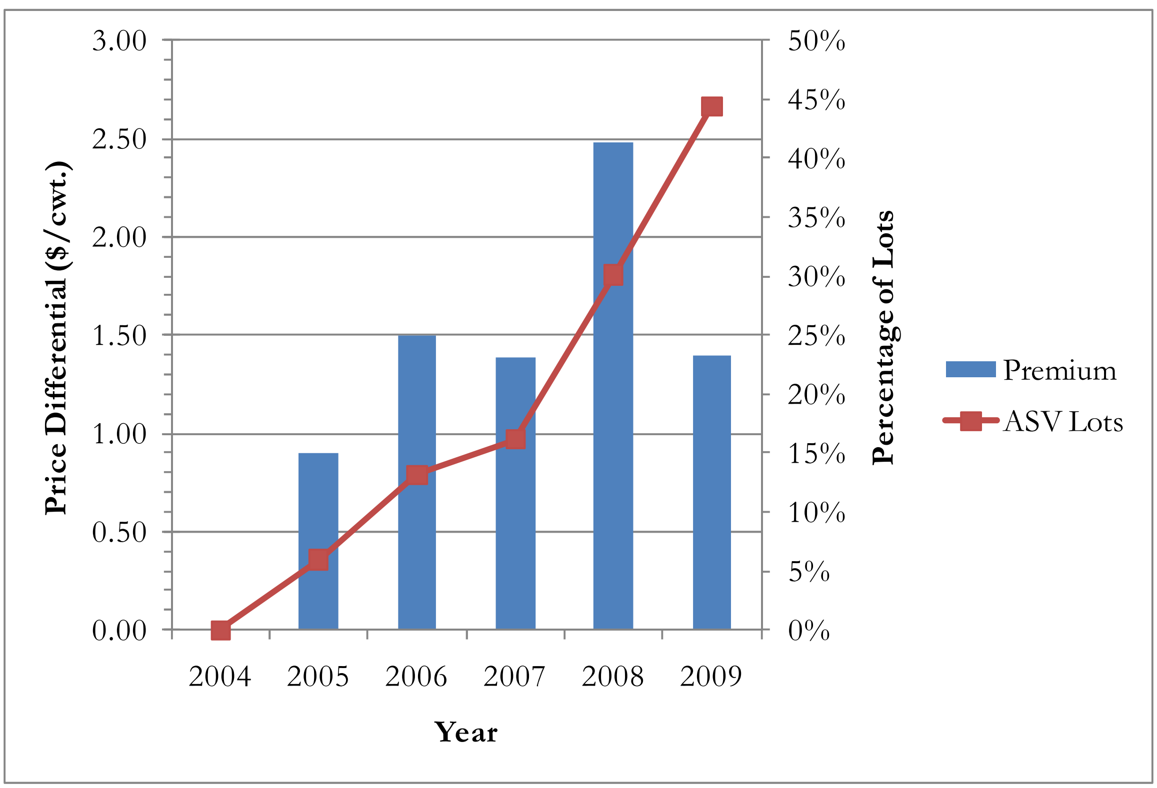


Figure 5.24 - Price Effect and Percentage of ASV Heifer Lots, 2004 to 2009



5.2.5 Price Effect of Market Conditions

Feeder cattle futures prices were used as a proxy variable for seasonal price variation and feeder calf market conditions. Menzie et al. (1972) said the purpose of this variable is to remove the price variation that can occur during long-run price analysis. The coefficient estimates can also serve as an indicator for market efficiency. A value close to one indicates that SLA video markets are an efficient mechanism for reflecting national market conditions in sale prices. The long-run nature of feeder cattle futures prices make them useful as a proxy variable for price variation in multi-year analysis. The coefficient estimates become less reliable as an indicator for market efficiency in shorter time frames. Since these models represent a 12-month period, the coefficient estimates are less likely to be close to one. This is further supported by the F-test results for SLA market efficiency in Table 5.14. The coefficient estimates in the annual models were similar for steers and heifers and ranged anywhere from 0.32 to 0.77. Similar estimates were found in the seasonal hedonic pricing models developed in Schroeder et al. (1988).

Table 5.14 - SLA Market Efficiency F-test Results, 2004 to 2009

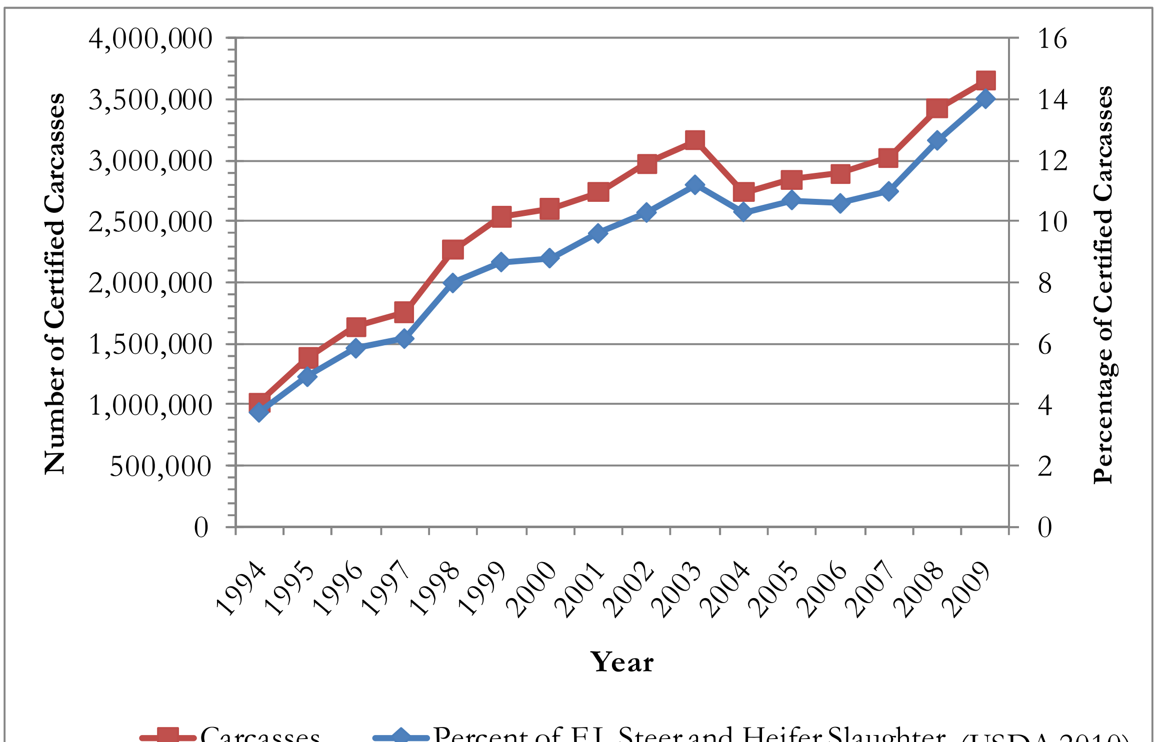
F-test description	Year	Null Hypothesis	Steers		Heifers	
			P-value	Test result	P-value	Test result
SLA market efficiency	2004	(22)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2005	(22)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2006	(22)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2007	(22)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2008	(22)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2009	(22)	< 0.0001	Reject H_0	< 0.0001	Reject H_0

CHAPTER 6 - Discussion

The price differentials expressed through the SLA video market represent the demand for individual calf traits that bring additional value to later beef production sectors. Vertical coordination in the beef industry has strengthened the price signals cow-calf producers receive for the genetic, management and marketing characteristics that are valued by stockers, feedlots, packers, restaurateurs and consumers.

Value-added management at the cow-calf level focuses on those characteristics most desired by the rest of the beef industry. That involves raising a healthy calf that grows efficiently and produces a high quality carcass. The demand for value-added calves can be illustrated through the evolution of branded beef programs (Figure 6.1). The number of USDA certified upper two-thirds Choice branded beef programs have increased nearly fourfold since 1994. Today's beef consumer expects a consistent, high-quality eating experience. Branded beef programs have filled a need in the market by representing specific quality attributes for beef consumers.

Figure 6.1 - Annual Upper 2/3 Choice Carcasses Produced for USDA Certified Beef Brands

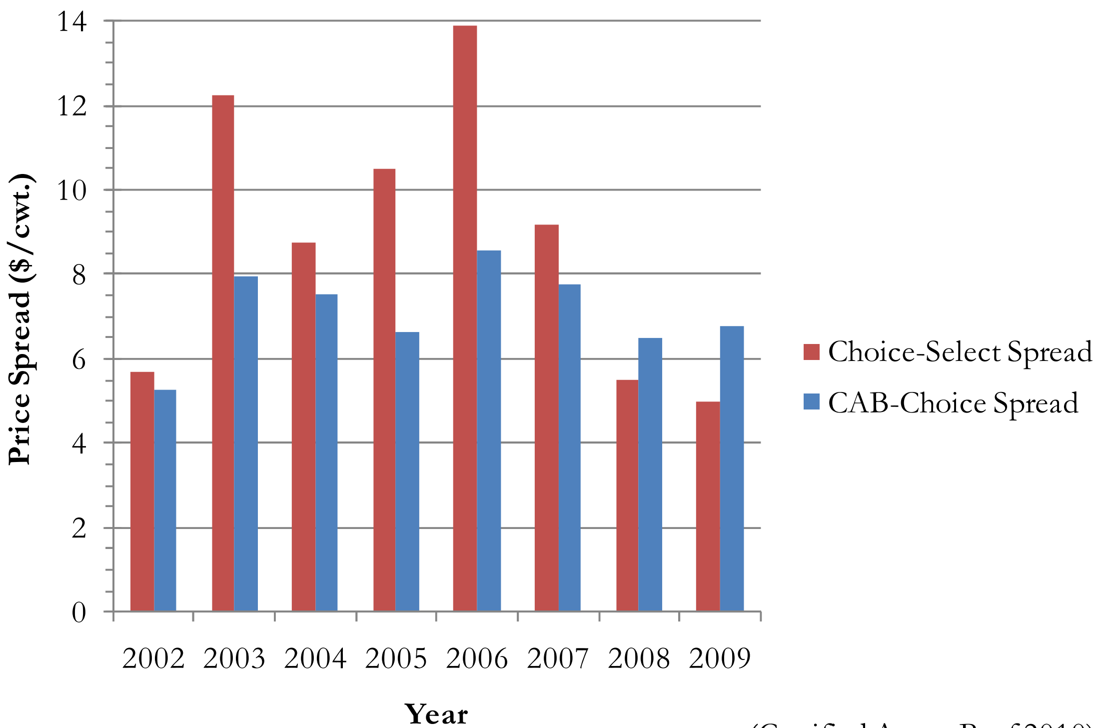


(USDA 2010)

Successful beef brands have been able to create a point of differentiation in the marketplace and consumers have been willing to pay a premium for those brands (Figure 6.2). The Certified

Angus Beef® brand illustrates how demand for a brand's specifications can influence changes at the cow-calf level. Consumer demand for the Certified Angus Beef® brand has created additional value for high-quality Angus carcasses at the packing sector. Packers recognize this additional profit opportunity and incentivize feedlots with premiums for Angus-influenced cattle that meet the brand's carcass specifications. Feedlots pass a portion of these benefits to cow-calf producers who can supply healthy, efficient Angus calves that are likely candidates for the brand (Certified Angus Beef 2006).

Figure 6.2 - Annual Choice-Select and Certified Angus Beef®- Choice Beef Price Spreads

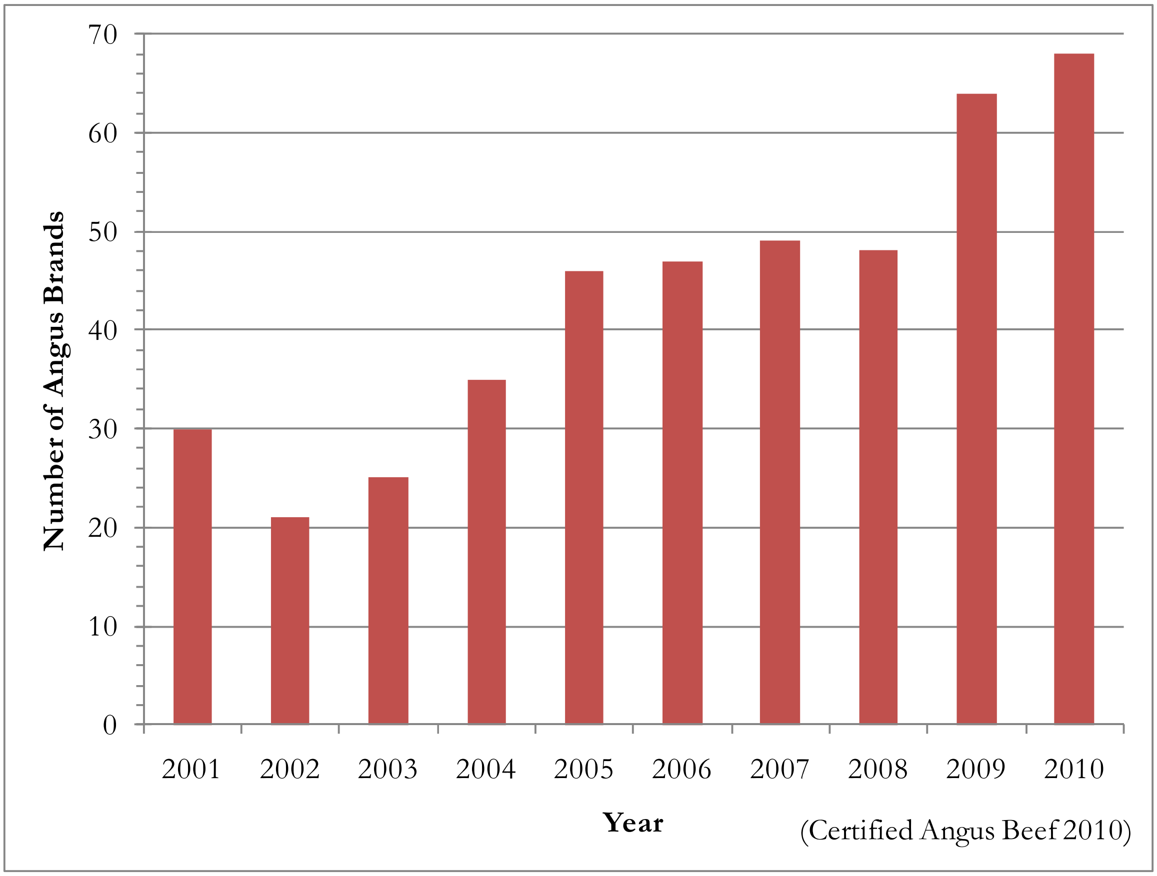


(Certified Angus Beef 2010)

The success of the Certified Angus Beef® brand and the marbling ability of Angus genetics have led to a growing number of USDA certified Angus beef brands (Figure 6.3). These additional Angus brands have continued to influence the genetic makeup of the commercial cowherd, and these trends can be seen in the breed influence change in SLA video market sales from 2004 to 2009 (Figure 5.9 and Figure 5.10). Preconditioning research has also illustrated the benefits of calf health to later efficiency and carcass quality. It is likely that increased demand for high-quality beef and specific branded beef programs has influenced the premiums cow-calf producers receive for genetic and health characteristics. These market influences have led to strong price signals for Angus genetics and integrated weaning and vaccination programs in SLA video market sales.

The price signals for Angus genetics and calf health programs evolved slowly over time. The Certified Angus Beef® brand started in 1978, and the preconditioning programs were first discussed in 1967 (Lalman and Smith 2001). Emerging natural and NHTC markets are possibly the next major vertically coordinated price influences to reach cow-calf producers. Domestic and foreign consumer preferences could continue to influence production standards, and lead to substantial premiums for a beef industry willing to embrace new opportunities to increase consumer demand.

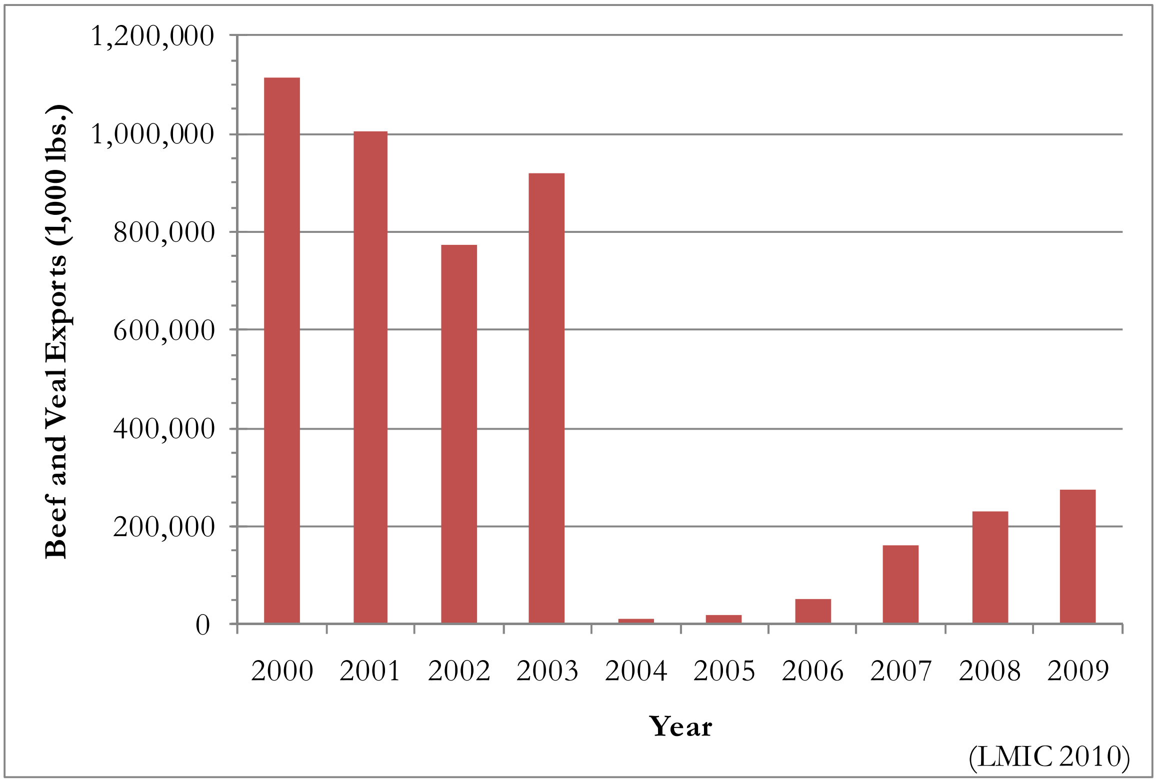
Figure 6.3 - Annual USDA Certified Angus Branded Beef Programs



Age-and-source verification is an example of how foreign market expectations have led to opportunities for U.S. cow-calf producers. U.S. beef exports to Japan must come from cattle 20 months of age or younger. These requirements have directly influenced ASV premiums. Discussions with feedlot managers have revealed that packing plants are paying feedlots $25 to $50 per head for ASV calves. The statistically significant SLA video market premium for ASV calves shows a portion of these premiums are being passed back to cow-calf producers. Premiums for ASV are directly tied to age restrictions in U.S. export markets, and Japan remains the country's largest export partner with these restrictions. The growth in ASV premiums and participation in Figure 5.23 and Figure

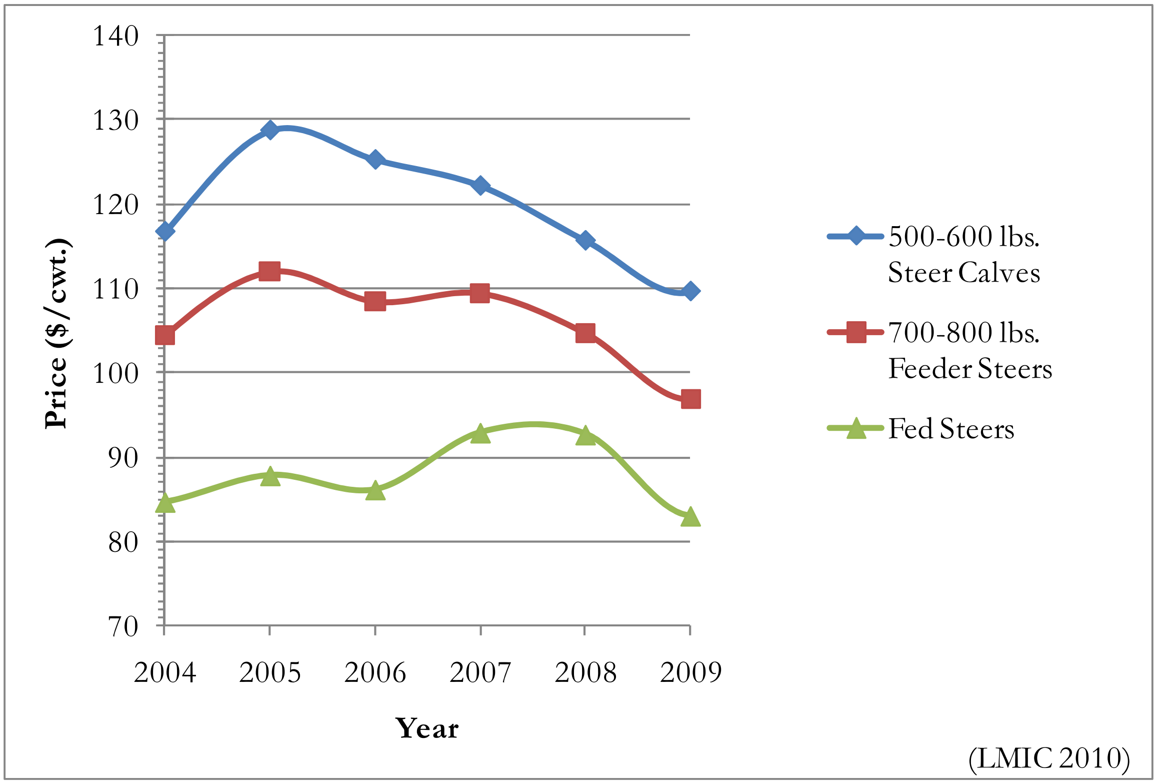
5.24 shows a similar trend to the growth in U.S. beef and veal exports in Japan since 2004 (Figure 6.4). As access to the Japanese beef market increases, premiums for ASV will continue to exist. However, it is likely that ASV premiums would disappear for cow-calf producers if Japan would ease trade restrictions and allow cattle 30 months and younger that can identified by physiological age. It is likely that export markets, such as Japan, benefit cow-calf producers beyond simply the premiums tied to ASV. They serve as an important market for end and variety meats that generally are not consumed in the U.S. These markets serve a valuable role in increasing the aggregate demand for U.S. beef and thus influence feeder calf prices.

Figure 6.4 - Annual U.S. Beef and Veal Exports to Japan



It is tempting for cow-calf producers to cut management corners when demand for feeder calves is high. The prevailing thought is that even mismanaged cattle make money when feeder calf markets are strong. Mark Harmon, manager at Joplin Regional Stockyards, Carthage, Missouri, told producers at the 2010 K-State Beef Conference that his experience has been the opposite. When feeder calf demand is high, Harmon said value-added calves earn higher premiums compared to weaker markets. Research from Dhuyvetter et al. (2005) found the opposite to be true with preconditioning premiums in late 1990s and early 2000s. They found that premiums generally declined as demand for feeder calves increased. The trend in annual average southern plains cattle prices (Figure 6.5) is similar to trends in SLA video market price differentials. In general, premiums for breed and health were more pronounced in 2006 and 2007 and declined steadily to 2009. The year-to-year variations in price differentials also share similarities to the Choice-Select and Certified Angus Beef®-Choice price spreads in Figure 6.2.

Figure 6.5 - Annual Average Southern Plains Cattle Prices



These discussion points lead to questions concerning future research opportunities in feeder calf hedonic modeling.

- How does the Choice-Select spread influence breed- and health-related feeder calf price differentials?
- What percentage of natural and NHTC market premiums are paid to participating cow-calf producers?
- How does export market availability influence feeder calf price differentials? Are ASV premiums at the cow-calf level more closely correlated to exports to Japan or the packer premiums paid to participating feedlots?
- What creates the year-to-year variation in feeder calf price differentials? How does feeder calf demand influence the implicit prices paid for feeder calf characteristics?

Some of these questions present natural extensions of the existing research model, while others can be answered through general inferences and trend analysis. Each reaches beyond the objectives of this research project. However, the increased cost of value-added management makes these questions increasingly relevant to cow-calf producers who are looking to manage the price risk of their additional investments in genetics, management and marketing.

CHAPTER 7 - Conclusion

The objective of this study was to determine the effect of value-added production on feeder calf prices in the SLA video market. The research estimated the price effect of various lot, genetic, management and marketing characteristics over a 14-year period of national video auction market sales. Vertical coordination within the beef industry has influenced management decision in the cow-calf sector through price determinants tied to integrated management practices. Agricultural economists have used hedonic pricing models in commodity research for more than 75 years to determine the implicit prices for input characteristics. Feeder cattle auction markets are one of the most thoroughly studied areas in commodity price analysis. Significant opportunities existed to apply existing research models to a database that represented the national supply and demand for feeder calf characteristics.

7.1 Application of Previous Research

Fredrick Waugh challenged agricultural economists to establish new research in the field of price theory with his 1928 paper “Quality Factors Influencing Vegetable Prices.” Ladd and Martin accepted Waugh’s challenge and developed the framework for hedonic pricing models that would be replicated throughout the agricultural economics field. In the early 1970s, James and Farris (1971) and Menzie et al. (1972) would establish the foundation for estimating feeder calf price effects using OLS multiple regression techniques. James and Farris would be the first agricultural economists to publish a weight-squared term to estimate non-linear price-weight relationship in cattle prices. Menzie et al. explained the use of this term in more detail and introduced the concept of using feeder cattle futures market prices as a proxy variable for estimating the effect of price variation in long-run feeder calf pricing models.

Feeder cattle price analysis in local and regional auction markets would become the focus of Extension bulletins and reports throughout the 1970s and 1980s. Research from Buccola (1980) and Marsh (1985) challenged agricultural economists to develop a more dynamic framework in the analysis of feeder cattle prices. They discussed the effect of expected profits on feeder cattle prices, and examined how expected costs of gain and fed cattle prices dictate the long-run price differences in calves and yearlings. Faminow and Gum (1986) highlighted the challenges outlined in Buccola’s comparative statics framework and the problems associated with linear estimators for certain price effects. The economists suggested using a lot-squared variable to capture non-linear price-lot size relationships, interaction terms for sex and year with weight, and dummy variables representing seasonality and auction markets. Schroeder et al. (1988) said that previous models had failed to account for relevant variables in feeder calf pricing models. The study added terms for health, horns, condition and fill.

Studies throughout the 1980s and 1990s focused on the value of preconditioned calves. The management practice was made popular through published research from the Texas A&M Ranch to Rail Program. Cow-calf producers have the burden of implementing preconditioning programs, and hedonic pricing models were used to estimate the auction market value of preconditioned calves and estimated budgets to determine the feasibility of ranch-level preconditioning. King et al. (2006) featured one of the first published studies focused on the price effects of various value-added calf health programs. Previous studies had looked at the general value of preconditioning; however, King et al. estimated the price effect of VAC 24, VAC 34, and VAC 45 programs in SLA video market sales. Kellom et al. (2008) continued to research the price effect of value-added management in the SLA video market by estimating the value of ASV calves in 2008. In 2006 and 2009, Blank et al. added to the body of video market research by estimating feeder calf pricing models using data from Western Video Market.

These studies provided the foundation for the hedonic pricing models developed in this study. Relevant terms and critical research findings determined the optimal model for expressing the statistically significant price determinants in SLA video market sales. Existing research frequently focused on local and regional market data and new research in feeder calf hedonics can provide insight into how vertical coordination in the cow-calf sector influences price effects. Current value-added management at the cow-calf level involves a combination of breeding, health and nutrition programs. Average sale prices based on bundled characteristics cannot account for the isolated effect of one management practice.

7.2 Results and Implications

Previous research has been unable to separate the individual price effects of integrated calf management practices such as preconditioning (Dhuyvetter et al. 2005, Kellom et al. 2008, and Blank et al. 2006 and 2009). The value of weaning and specific vaccination program management needs to be more clearly separated in feeder calf pricing models. Furthermore, the price effect for non-implanted, natural- and NHTC-market eligible calves are different based on the management necessary to meet the marketing program requirement. A failure to separate these bundled management practices has the potential to mislead cow-calf producers on the revenue opportunities that exist for specific management practices that have evolved in the last 10 years. The majority of U.S. cow-calf producers sell calves at auction market. The price signals delivered through the SLA video market provide cattlemen with a snapshot of those management practices that are likely to add value to their calf crop. The cost and feasibility of these management practices need to be examined at the individual ranch level. Some management practices offer more opportunities for profit than others, and cow-calf producers should prioritize their calf management decisions based on ease of adoption and market profitability.

More intensive value-added management practices were expected to enhance the revenue of cow-calf producers selling through video auction markets. The research shows that verified genetic and health claims produce higher calf sale prices compared to commodity calves. Subtle genetic, management and marketing trait details can have a statistically significant influence on calf prices. Producers who describe their calves as "weaned, non-implanted, black-hided calves with all their shots" could be missing chances for additional revenue.

Buyers appear to be more discriminating in seller management and marketing claims. Statistical price differences existed in certain sale periods between Angus and black or black-white faced calves. Similar differences were observed between verified health claims and non-certified respiratory vaccination and weaning programs. Premiums for natural-market eligible cattle are relatively small, but creating a point of differentiation between these and non-implanted calves is often as simple as documenting and verifying ranch management practices. If ranch recordkeeping already includes calf birth dates, ASV might offer additional sale revenue. The price differences that exist for these management adjustments can be small and unpredictable at times, but many of these management decisions can be implemented with incremental adjustments. A small distinction in management and marketing details can improve calf revenue $1 to $2 per cwt. and have a substantial influence on per head net profit.

Auction market premiums exist for calves with advanced herd management traits. What management practices offer the best opportunity for revenue enhancement? The research shows that breed and health-related management traits consistently offered the best opportunity to capture increased revenue based on the estimated price determinants (Figure 7.1).

Buyers preferred weaned calves with at least two rounds of respiratory vaccinations. Compared to non-weaned, non-vaccinated calves, premiums for these health programs generated an additional $5.50 to $7.50 per cwt. to the price of steers and heifers. Weaning can create an additional

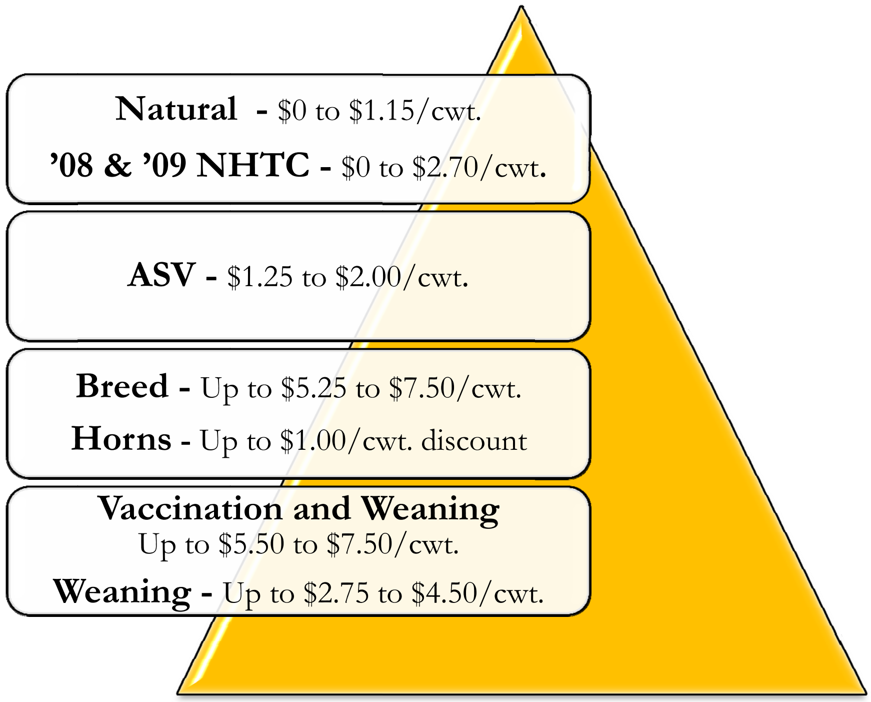
$2.75 to $4.50 per cwt. in non-certified health programs. Cow-calf producers that are unable to wean their calves, but are open to administering respiratory vaccinations should consider the VAC 34 protocol. There was a statistical difference in the premiums generated for VAC 34 protocol compared to single respiratory vaccinations in non-certified health programs. Angus and black or black-white faced calves were consistently at a premium to Brahman-influenced calves.

There were statistical differences among the premiums for each aggregated breed influence, and Angus and black and black-white faced cattle consistently generated an additional $5.25 to $7.50 per cwt. over cattle with ear. Horned calves were also discounted in SLA video market sales. Cow-calf producers should make sure that polled genetics are a focus in herd breeding programs. Avoiding horns in sale calves can improve prices an additional $1 per cwt.

Marketing programs for ASV, natural and NHTC certified cattle have emerged in the last six years as domestic and international consumers have demanded specific management practices from U.S. beef producers. Age-and-source verification presents the best opportunity for calf premiums. Statistically significant premiums ranging from $1.25 to $2 per cwt. existed for both steers and heifers in each of the last five years. Natural and NHTC market premiums are less consistent over the last six years. Producers who have made a conscious decision to not implant calves can explore these programs and potentially receive an additional $1.15 to $2.70 per cwt. for documenting management claims. It is important to note that implanted calves are not penalized in the marketplace. Cow-calf producers who can benefit from the efficiency gains of implants at the ranch do not receive lower calf prices based on these results.

Previous research results were also confirmed in this study. Total revenue for cow-calf producers is largely dependent on calf weight, and the price-weight relationship is generally non-linear in SLA calf sales. Weight variation within a sale lot has important implications to management in later sectors. Producers should manage breeding and nutrition programs to develop a group of calves with as little weight variation as possible. Producers should focus on raising calves of average or larger frame size and target calf nutrition programs to avoid heavy flesh conditions at sale time. A target for optimal lot size is not as important as other management traits in SLA video sales given that most sale lots are already truckload size (40,000 lbs.) or larger. Also, region of origin continued to have a statistically significant influence on price. Calves from the Southeast and West were consistently discounted on the SLA video market compared to calves from the South Central region.

Figure 7.1 - Opportunities for Additional Value-Added Calf Revenue in the SLA Video Market



7.3 Model Limitations

Feeder calf price analysis using the SLA video market database estimates the preferences of a national marketplace. Cow-calf producers can apply the results of this study to their local environment to determine the best management practices for improving profits. However, it is important to realize that national pricing trends are not always reflected at the local level. The price differentials expressed across local markets can differ considerably, and the SLA video market takes these differences to a national level. The estimated price effects are useful in understanding the relative influence of specific management on price, and the various genetic, management and marketing traits expressed through the video market study should be interpreted in that manner.

The hedonic pricing models estimated in the research used the best available characteristics in determining price effect, but there a few considerations to be made when evaluating the results. Price slide and shrink information was not incorporated in the analysis. These forward contract terms can be valuable in determining the weight risk associated with a sale lot. Previous research from Bailey et al. (1991) estimated a statistically significant effect for weight risk in hedonic models using SLA video market data. Also, the databases represented in this model do not represent all of the cattle sold in SLA video market sales. Data were collected by a third-party provider and resource restrictions led to a reduction in the number of sale lots recorded beginning in 2006. Noticeable population changes were noted in the database in 2006 and 2007. Data collection bias did not appear to affect the statistical significance or relative importance of coefficient estimates, but noticeable changes in the population did make it more difficult to look at producer participation in certain management and marketing activities.

7.4 Summary

Value-added management at the cow-calf sector has a positive influence on calf price in the SLA video market. Cattlemen who would like to improve the profitability of their calves should first focus on the revenue-enhancing improvements that can be made in health and breeding programs. Considerations for additional management and marketing practices include ASV, natural and NHTC markets. The potential for increased marginal revenue from these programs is considerably less than the other management practices; however, each of these programs could become increasingly more important as demand increases for the production standards they encompass. Previous research concerning the relationship of frame size, flesh, weight, weight variation and lot size to price still apply in SLA video market sales. Producers that embrace value-added management and marketing opportunities are likely to receive a higher price for their calves than commodity cattle. Statistically significant premiums can be noted among incremental management adjustments for breed and health programs. Producers should focus on improving management and marketing practices that produce the highest increase in net revenue without creating excessive cost and management burdens.

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Appendix A - 1996 to 2007 Hedonic Pricing Models

Table A.1 - 1996 to 1999 Average Price, Lot, Weight, Sale and Delivery Data

Mean variable	Steers - 450 to 750 lbs.				Heifers - 400 to 700 lbs.			
	Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum
Sale price ($ per cwt.)	$80.75	12.03	$41.25	$116.00	$74.87	11.77	$39.35	$104.50
Nearby feeder cattle futures contract ($ per cwt.)	$73.20	7.15	$51.82	$84.77	$73.04	7.14	$51.82	$84.77
Lot size (# of head)	120.57	73.68	20	900	115.36	60.91	20	800
Base weight (lbs.)	565.19	63.50	450	750	524.64	61.85	400	700
Sale month (# of month)	7.50	2.30	1	12	7.30	2.59	1	12
Delivery month (# of month)	9.33	2.59	1	12	8.97	2.95	1	12
Days to delivery (days between sale and delivery)	55.58	38.75	0	175	50.88	39.31	0	174

Table A.2 - 1996 to 1999 Means for Hedonic Pricing Model

Characteristic	Variable description	Steers - 450 to 750 lbs. Observations		Heifers - 400 to 700 lbs. Observations	
		(# of lots)	(% of lots)	(# of lots)	(% of lots)
Frame	Small to medium	2728	41.35%	1989	43.58%
	Medium to medium-large mix	2809	42.58%	1940	42.51%
	Medium-large to large	1060	16.07%	635	13.91%
Flesh	Light to light-medium	266	4.03%	243	5.32%
	Light-medium to medium mix	507	7.69%	416	9.11%
	Medium	5481	83.08%	3701	81.09%
	Medium to medium-heavy mix to heavy	343	5.20%	204	4.47%
Weight variation	Even to fairly even	468	7.09%	251	5.50%
(uniformity)	Uneven	5934	89.95%	4161	91.17%
	Very uneven	195	2.96%	152	3.33%
Implant	Not implanted	2662	40.35%	2402	52.63%
	Unknown or some implanted	203	3.08%	214	4.69%
	Implanted	3732	56.57%	1948	42.68%
Vaccination	Not vaccinated	1309	19.84%	878	19.24%
	VAC 24 and VAC 34	1468	22.25%	891	19.52%
	VAC 45	350	5.31%	199	4.36%
	One respiratory vaccination	2721	41.25%	2076	45.49%
	Two or more respiratory vaccinations	749	11.35%	520	11.39%
Weaning	Weaned calves	1971	29.88%	1638	35.89%
	Weaning w/ respiratory vaccination	1621	24.57%	1439	31.53%
Bangs vaccinated	Vaccinated			1050	23.01%
Horns	Some, tipped and all horns	805	12.20%	731	16.02%
Breed	Cattle w/ ear	1796	27.22%	1336	29.27%
	English & English cross	1237	18.75%	689	15.10%
	Continental & Continental cross	68	1.03%	52	1.14%
	English/Continental cross	3194	48.42%	2304	50.48%
	Black, black-white-faced and Angus	302	4.58%	183	4.01%
Region of origin	West	1248	18.92%	861	18.87%
	Rocky Mountain/North Central	3066	46.48%	1901	41.65%
	South Central	1738	26.35%	1355	29.69%
	Southeast	545	8.26%	447	9.79%

Table A.3 - 1996 to 1999 Coefficients Estimates for Hedonic Pricing Model

Characteristic	Variable description	Steers - 450 to 750 lbs.			Heifers - 400 to 700 lbs.		
		Observ. (lots)	Coefficient Estimates	P-Value (P>|t|)	Observ. (lots)	Coefficient Estimates	P-Value (P>|t|)
Intercept	Intercept	6597	27.9681	< 0.0001	4564	-16.7270	< 0.0001
Lot size	Number of head	6597	0.0122	< 0.0001	4564	0.0089	0.0011
(Lot size)^2	Number of head squared	6597	-0.00001	< 0.0001	4564	-0.00001	0.0967
Weight	Average base weight of lot	6597	-0.1563	< 0.0001	4564	-0.0444	0.0013
(Weight)^2	Average base weight of lot squared	6597	0.00009	< 0.0001	4564	0.00001	0.4906
Frame	Small to medium	2728	0.1362	0.2094	1989	0.0883	0.5068
	Medium to medium-large mix	2809	Base		1940	Base	
	Medium-large to large	1060	0.0134	0.9167	635	-0.0967	0.5743
Flesh	Light to light-medium	266	1.3519	< 0.0001	243	1.8139	< 0.0001
	Light-medium to medium mix	507	1.1667	< 0.0001	416	1.1272	< 0.0001
	Medium	5481	Base		3701	Base	
	Medium to medium-heavy mix to heavy	343	-0.6195	0.0015	204	-0.0375	0.8939
Weight variation	Even to fairly even	468	0.2689	0.1281	251	0.8715	0.0006
(uniformity)	Uneven	5934	Base		4161	Base	
	Very uneven	195	-0.7468	0.0175	152	-0.9111	0.0065
Implant	Not implanted	2662	Base		2402	Base	
	Unknown or some implanted	203	-1.0482	0.0005	214	-0.3079	0.263
	Implanted	3732	0.0265	0.7958	1948	0.0617	0.6168
Vaccination	Not vaccinated	1309	Base		878	Base	
	VAC 24 and VAC 34	1468	1.4480	< 0.0001	891	1.2032	< 0.0001
	VAC 45	350	2.2798	< 0.0001	199	1.5715	< 0.0001
	One respiratory vaccination	2721	0.9004	< 0.0001	2076	0.7639	< 0.0001
	Two or more respiratory vaccinations	749	1.0761	< 0.0001	520	0.7028	0.0046
	Weaning w/ respiratory vaccination	1621	1.9887	< 0.0001	1439	1.7518	< 0.0001
Bangs vaccinated	Not vaccinated or unknown				3514	Base	
	Vaccinated				1050	0.4455	0.0163
Horns	No horns	5792	Base		3833	Base	
	Some, tipped and all horns	805	-0.1661	0.3945	731	-0.7547	0.0004
Breed	Cattle w/ ear	1796	Base		1336	Base	
	English & English cross	1237	2.7494	< 0.0001	689	2.7658	< 0.0001
	Continental & Continental cross	68	2.4540	< 0.0001	52	1.6010	0.0033
	English/Continental cross	3194	2.3929	< 0.0001	2304	1.9485	< 0.0001
	Black, black-white-faced and Angus	302	3.0484	< 0.0001	183	4.0079	< 0.0001
Price variation	Feeder cattle futures price	6597	1.4733	< 0.0001	4564	1.4881	< 0.0001
Region of origin	West	1248	-1.8926	< 0.0001	861	-2.0191	< 0.0001
	Rocky Mountain/North Central	3066	0.4642	0.0038	1901	0.7593	0.0001
	South Central	1738	Base		1355	Base	
	Southeast	545	-4.8385	< 0.0001	447	-4.6140	< 0.0001
Days to delivery	Days between sale and delivery date	6597	0.0060	< 0.0001	4564	0.0058	0.0007
Analysis of Variance and Homoskedasticity		***Adj. R^2 Value:*** *0.9006*			***Adj. R^2 Value:*** *0.8896*		
		Root MSE: *3.79156*			***Root MSE:*** *3.91220*		
		White Test Results: *P>Chi^2 < 0.0001*			***White Test Results:*** *P>Chi^2 < 0.0001*		
		DF = 385, Chi-Square = 742.09			*DF = 413, Chi-Square = 683.76*		

Table A.4 - 2000 to 2003 Average Price, Lot, Weight, Sale and Delivery Data

Mean variable	Steers - 450 to 750 lbs.				Heifers - 400 to 700 lbs.			
	Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum
Sale price ($ per cwt.)	$98.19	10.35	$70.00	$130.50	$92.81	9.52	$66.75	$127.00
Nearby feeder cattle futures contract ($ per cwt.)	$86.25	5.41	$74.80	$105.63	$86.12	5.46	$74.80	$105.63
Lot size (# of head)	123.57	77.79	40	1000	116.04	63.97	23	850
Base weight (lbs.)	565.92	66.49	450	750	528.09	64.62	400	700
Sale month (# of month)	6.89	2.37	1	12	6.72	2.58	1	12
Delivery month (# of month)	9.05	2.77	1	12	8.77	3.04	1	12
Days to delivery (days between sale and delivery)	65.32	44.20	0	180	62.46	45.26	0	180

Table A.5 - 2000 to 2003 Means for Hedonic Pricing Model

Characteristic	Variable description	Steers - 450 to 750 lbs.		Heifers - 400 to 700 lbs.	
		Observations		Observations	
		(# of lots)	(% of lots)	(# of lots)	(% of lots)
Frame	Small to medium	4150	44.46%	3347	47.68%
	Medium to medium-large mix	4051	43.40%	3018	42.99%
	Medium-large to large	1133	12.14%	655	9.33%
Flesh	Light to light-medium	525	5.62%	465	6.62%
	Light-medium to medium mix	757	8.11%	671	9.56%
	Medium	7759	83.13%	5697	81.15%
	Medium to medium-heavy mix to heavy	293	3.14%	187	2.66%
Weight variation	Even to fairly even	640	6.86%	429	6.11%
(uniformity)	Uneven	8347	89.43%	6266	89.26%
	Very uneven	347	3.72%	325	4.63%
Implant	Not implanted	4696	50.31%	4307	61.35%
	Unknown or some implanted	303	3.25%	345	4.91%
	Implanted	4335	46.44%	2368	33.73%
Vaccination	Not vaccinated	772	8.27%	560	7.98%
	VAC 24	268	2.87%	220	3.13%
	VAC34	2640	28.28%	1714	24.42%
	VAC 45	1193	12.78%	879	12.52%
	VAC Precon	131	1.40%	59	0.84%
	One respiratory vaccination	2612	27.98%	2243	31.95%
	Two or more respiratory vaccinations	1718	18.41%	1345	19.16%
Weaning	Weaned calves	3540	37.93%	2946	41.97%
	Weaning w/ respiratory vaccination	2216	23.74%	2008	28.60%
Bangs vaccinated	Vaccinated			1423	20.27%
Horns	Some, tipped and all horns	1172	12.56%	1086	15.47%
Breed	Cattle w/ ear	2633	28.21%	2174	30.97%
	English & English cross	920	9.86%	581	8.28%
	Continental & Continental cross	237	2.54%	172	2.45%
	English/Continental cross	3761	40.29%	2896	41.25%
	Black & black-white-faced	1239	13.27%	852	12.14%
	Predominantly Angus	544	5.83%	345	4.91%
Region of origin	West	1716	18.38%	1358	19.34%
	Rocky Mountain/North Central	4144	44.40%	2876	40.97%
	South Central	2606	27.92%	2038	29.03%
	Southeast	868	9.30%	748	10.66%

Table A.6 - 2000 to 2003 Coefficients Estimates for Hedonic Pricing Model

Characteristic	Variable description	Steers - 450 to 750 lbs. Observ. (lots)	Coefficient Estimates	P-Value (P>|t|)	Heifers - 400 to 700 lbs. Observ. (lots)	Coefficient Estimates	P-Value (P>|t|)
Intercept	Intercept	9334	104.7497	< 0.0001	7020	70.5389	< 0.0001
Lot size	Number of head	9334	0.0106	< 0.0001	7020	0.0127	< 0.0001
(Lot size)^2	Number of head squared	9334	-0.00001	0.0075	7020	-0.00001	0.0096
Weight	Average base weight of lot	9334	-0.3247	< 0.0001	7020	-0.2338	< 0.0001
(Weight)^2	Average base weight of lot squared	9334	0.00021	< 0.0001	7020	0.00015	< 0.0001
Frame	Small to medium	4150	-0.0245	0.8247	3347	0.1328	0.2823
	Medium to medium-large mix	4051	Base		3018	Base	
	Medium-large to large	1133	-0.0164	0.9159	655	0.7150	0.0002
Flesh	Light to light-medium	525	1.1473	< 0.0001	465	1.3793	< 0.0001
	Light-medium to medium mix	757	1.1281	< 0.0001	671	0.7900	0.0005
	Medium	7759	Base		5697	Base	
	Medium to medium-heavy mix to heavy	293	-0.7120	0.0096	187	-0.3538	0.265
Weight variation	Even to fairly even	640	0.6896	0.0004	429	1.1676	< 0.0001
(uniformity)	Uneven	8347	Base		6266	Base	
	Very uneven	347	-1.4436	< 0.0001	325	-1.3235	< 0.0001
Implant	Not implanted	4696	Base		4307	Base	
	Unknown or some implanted	303	-1.0655	0.0002	345	0.0598	0.8064
	Implanted	4335	0.2579	0.0169	2368	0.0672	0.6097
Vaccination	Not vaccinated	772	Base		560	Base	
	VAC 24	268	1.4199	< 0.0001	220	1.5576	< 0.0001
	VAC 34	2640	1.4674	< 0.0001	1714	0.9175	< 0.0001
	VAC 45	1193	3.6508	< 0.0001	879	2.9761	< 0.0001
	VAC Precon	131	5.2203	< 0.0001	59	3.5886	< 0.0001
	One respiratory vaccination	2612	1.3470	< 0.0001	2243	0.8041	0.0011
	Two or more respiratory vaccinations	1718	2.0614	< 0.0001	1345	1.1145	< 0.0001
	Weaning w/ respiratory vaccination	2216	2.8358	< 0.0001	2008	2.8917	< 0.0001
Bangs vaccinated	Not vaccinated or unknown				5597	Base	
	Vaccinated				1423	0.4816	0.0059
Horns	No horns	8162	Base		5934	Base	
	Some, tipped and all horns	1172	-0.1066	0.5900	1086	-0.2397	0.2086
Breed	Cattle w/ ear	2633	Base		2174	Base	
	English & English cross	920	2.1134	< 0.0001	581	2.1543	< 0.0001
	Continental & Continental cross	237	2.5035	< 0.0001	172	1.2688	0.0007
	English/Continental cross	3761	2.7442	< 0.0001	2896	2.2890	< 0.0001
	Black & black-white-faced	1239	3.4803	< 0.0001	852	3.5244	< 0.0001
	Predominantly Angus	544	4.9395	< 0.0001	345	5.8716	< 0.0001
Price variation	Feeder cattle futures price	9334	1.1847	< 0.0001	7020	1.1171	< 0.0001
Region of origin	West	1716	-2.2978	< 0.0001	1358	-2.2890	< 0.0001
	Rocky Mountain/North Central	4144	0.6413	0.0003	2876	1.1086	< 0.0001
	South Central	2606	Base		2038	Base	
	Southeast	868	-4.0683	< 0.0001	748	-3.1321	< 0.0001
Days to delivery	Days between sale and delivery date	9334	0.0294	< 0.0001	7020	0.0260	< 0.0001
Analysis of Variance and Homoskedasticity		***Adj. R^2 Value:*** *0.7889*			***Adj. R^2 Value:*** *0.7612*		
		Root MSE: *4.75580*			***Root MSE:*** *4.65410*		
		White Test Results: *P>Chi^2 < 0.0001*			***White Test Results:*** *P>Chi^2 < 0.0001*		
		DF = 457, Chi-Square = 1059.17			*DF = 489, Chi-Square = 864.7*		

Table A.7 - 2004 to 2005 Average Price, Lot, Weight, Sale and Delivery Data

Mean variable	Steers - 450 to 750 lbs.				Heifers - 400 to 700 lbs.			
	Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum
Sale price ($ per cwt.)	$123.53	10.99	$87.50	$164.75	$118.10	10.45	$84.00	$162.50
Nearby feeder cattle futures contract ($ per cwt.)	$106.50	6.60	$82.45	$117.65	$106.02	7.16	$82.45	$117.65
Lot size (# of head)	121.32	76.69	24	1050	114.78	70.80	35	1100
Base weight (lbs.)	580.66	69.95	450	750	542.81	66.00	400	700
Sale month (# of month)	6.77	2.31	1	12	6.60	2.47	1	12
Delivery month (# of month)	9.12	2.68	1	12	8.89	2.88	1	12
Days to delivery (days between sale and delivery)	74.35	46.18	0	180	72.47	47.57	1	180

Table A.8 - 2004 to 2005 Means for Hedonic Pricing Model

Characteristic	Variable description	Steers - 450 to 750 lbs.		Heifers - 400 to 700 lbs.	
		Observations		Observations	
		(# of lots)	(% of lots)	(# of lots)	(% of lots)
Frame	Small to medium	2576	40.08%	1939	42.60%
	Medium to medium-large mix	2963	46.10%	2143	47.08%
	Medium-large to large	888	13.82%	470	10.33%
Flesh	Light to light-medium	377	5.87%	272	5.98%
	Light-medium to medium mix	538	8.37%	440	9.67%
	Medium	5315	82.70%	3722	81.77%
	Medium to medium-heavy mix to heavy	197	3.07%	118	2.59%
Weight variation	Even to fairly even	475	7.39%	296	6.50%
(uniformity)	Uneven	5695	88.61%	4044	88.84%
	Very uneven	257	4.00%	212	4.66%
Implant	Not implanted	2546	39.61%	2263	49.71%
	Natural eligible - Not implanted	1415	22.02%	986	21.66%
	Unknown or some implanted	165	2.57%	145	3.19%
	Implanted	2301	35.80%	1158	25.44%
Vaccination	Not vaccinated	207	3.22%	140	3.08%
	VAC 24	386	6.01%	232	5.10%
	VAC34	2290	35.63%	1484	32.60%
	VAC 45	1243	19.34%	868	19.07%
	VAC Precon	361	5.62%	229	5.03%
	One respiratory vaccination	1028	16.00%	873	19.18%
	Two or more respiratory vaccinations	912	14.19%	726	15.95%
Weaning	Weaned calves	2753	42.83%	2124	46.66%
	Weaning w/ respiratory vaccination	1149	17.88%	1027	22.56%
Bangs vaccinated	Vaccinated			358	7.86%
Age-and-source verified	Enrolled in program	225	3.50%	141	3.10%
Horns	Some, tipped and all horns	919	14.30%	842	18.50%
Breed	Cattle w/ ear	1799	27.99%	1467	32.23%
	English & English cross	554	8.62%	317	6.96%
	Continental & Continental cross	95	1.48%	60	1.32%
	English/Continental cross	2438	37.93%	1764	38.75%
	Black & black-white-faced	1256	19.54%	782	17.18%
	Predominantly Angus	285	4.43%	162	3.56%
Region of origin	West	1022	15.90%	727	15.97%
	Rocky Mountain/North Central	2692	41.89%	1781	39.13%
	South Central	2225	34.62%	1635	35.92%
	Southeast	488	7.59%	409	8.99%

Table A.9 - 2004 to 2005 Coefficients Estimates for Hedonic Pricing Model

Characteristic	Variable description	Steers - 450 to 750 lbs.			Heifers - 400 to 700 lbs.		
		Observ. (lots)	Coefficient Estimates	P-Value (P>|t|)	Observ. (lots)	Coefficient Estimates	P-Value (P>|t|)
Intercept	Intercept	6427	196.2722	< 0.0001	4552	157.4615	< 0.0001
Lot size	Number of head	6427	0.0195	< 0.0001	4552	0.0179	< 0.0001
(Lot size)^2	Number of head squared	6427	-0.00002	< 0.0001	4552	-0.00002	0.0005
Weight	Average base weight of lot	6427	-0.4653	< 0.0001	4552	0.3720	< 0.0001
(Weight)^2	Average base weight of lot squared	6427	0.00030	< 0.0001	4552	0.00025	< 0.0001
Frame	Small to medium	2576	-0.4821	0.0007	1939	-0.5293	0.0018
	Medium to medium-large mix	2963	Base		2143	Base	
	Medium-large to large	888	0.3145	0.1133	470	-0.0045	0.9859
Flesh	Light to light-medium	377	0.5871	0.0645	272	1.7418	< 0.0001
	Light-medium to medium mix	538	1.6966	< 0.0001	440	0.8792	0.0033
	Medium	5315	Base		3722	Base	
	Medium to medium-heavy mix to heavy	197	-1.4702	< 0.0001	118	-0.9468	0.0267
Weight variation	Even to fairly even	475	0.9557	0.0001	296	2.2924	< 0.0001
(uniformity)	Uneven	5695	Base		4044	Base	
	Very uneven	257	-1.3195	0.0002	212	-1.3857	0.001
Implant	Not implanted	2546	Base		2263	Base	
	Natural eligible - Not implanted	1415	0.6089	0.0005	986	0.6327	0.0021
	Unknown or some implanted	165	-0.5677	0.1708	145	-0.2925	0.4869
	Implanted	2301	0.6404	< 0.0001	1158	-0.1845	0.3358
Vaccination	Not vaccinated	207	Base		140	Base	
	VAC 24	386	2.6089	< 0.0001	232	2.0033	0.0006
	VAC 34	2290	3.3320	< 0.0001	1484	2.1160	< 0.0001
	VAC 45	1243	6.8081	< 0.0001	868	5.1941	< 0.0001
	VAC Precon	361	7.7904	< 0.0001	229	4.2833	< 0.0001
	One respiratory vaccination	1028	2.0475	< 0.0001	873	0.7826	0.1508
	Two or more respiratory vaccinations	912	3.1615	< 0.0001	726	1.5254	0.01
	Weaning w/ respiratory vaccination	1149	3.5350	< 0.0001	1027	3.3416	< 0.0001
Bangs vaccinated	Not vaccinated or unknown				4194	Base	
	Vaccinated				358	1.1200	0.0003
Age-and-source-verified	No	6202	Base		4411	Base	
	Yes	225	0.6924	0.0135	141	0.7389	0.0302
Horns	No horns	5508	Base		3710	Base	
	Some, tipped and all horns	919	-0.9557	0.0002	842	-0.3913	0.1413
Breed	Cattle w/ear	1799	Base		1467	Base	
	English & English cross	554	4.0890	< 0.0001	317	3.8817	< 0.0001
	Continental & Continental cross	95	3.3589	< 0.0001	60	2.3436	< 0.0001
	English/Continental cross	2438	3.8991	< 0.0001	1764	3.3900	< 0.0001
	Black & black-white-faced	1256	5.4641	< 0.0001	782	5.1483	< 0.0001
	Predominantly Angus	285	6.2225	< 0.0001	162	8.1735	< 0.0001
Price variation	Feeder cattle futures price	6427	0.7764	< 0.0001	4552	0.7463	< 0.0001
Region of origin	West Coast	1022	-3.4228	< 0.0001	727	-2.8754	< 0.0001
	Rocky Mountain/North Central	2692	0.1277	0.5658	1781	0.4195	0.1132
	South Central	2225	Base		1635	Base	
	Southeast	488	-3.8701	< 0.0001	409	-2.8982	< 0.0001
Days to delivery	Days between sale and delivery date	6427	0.0287	< 0.0001	4552	0.0241	< 0.0001
Analysis of Variance and Homoskedasticity		***Adj. R^2 Value:*** *0.7878* ***Root MSE:*** *5.06405*			***Adj. R^2 Value:*** *0.7645* ***Root MSE:*** *5.07241*		
		White Test Results: *P>Chi^2 < 0.0001* *DF = 516, Chi-Square = 860.49*			***White Test Results:*** *P>Chi^2 < 0.0001* *DF = 545, Chi-Square = 1189.58*		

Table A.10 - 2006 to 2007 Average Price, Lot, Weight, Sale and Delivery Data

Mean variable	Steers - 450 to 750 lbs.				Heifers - 400 to 700 lbs.			
	Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum
Sale price ($ per cwt.)	$124.50	9.82	$97.00	$170.00	$118.49	9.21	$90.75	$161.00
Nearby feeder cattle futures contract ($ per cwt.)	$114.27	3.71	$102.90	$119.48	$114.40	3.62	$102.90	$119.48
Lot size (# of head)	121.50	70.23	20	760	115.28	63.51	22	700
Base weight (lbs.)	580.61	70.53	450	750	539.69	66.33	400	700
Sale month (# of month)	7.37	0.99	5	9	7.39	1.00	5	9
Delivery month (# of month)	9.93	1.36	1	12	9.90	1.46	1	12
Days to delivery (days between sale and delivery)	80.85	38.37	0	180	80.21	38.87	1	180

Table A.11 - 2006 to 2007 Means for Hedonic Pricing Model

Characteristic	Variable description	Steers - 450 to 750 lbs. Observations		Heifers - 400 to 700 lbs. Observations	
		(# of lots)	(% of lots)	(# of lots)	(% of lots)
Frame	Small to medium	1935	43.40%	1252	44.92%
	Medium to medium-large mix	2003	44.92%	1235	44.31%
	Medium-large to large	521	11.68%	300	10.76%
Flesh	Light to light-medium	164	3.68%	128	4.59%
	Light-medium to medium mix	263	5.90%	180	6.46%
	Medium	3888	87.19%	2411	86.51%
	Medium to medium-heavy mix to heavy	144	3.23%	68	2.44%
Weight variation	Even to fairly even	309	6.93%	146	5.24%
(uniformity)	Uneven	3995	89.59%	2521	90.46%
	Very uneven	155	3.48%	120	4.31%
Implant	Not implanted	1466	32.88%	1106	39.68%
	Natural eligible - Not implanted	1595	35.77%	995	35.70%
	Unknown or some implanted	117	2.62%	100	3.59%
	Implanted	1281	28.73%	586	21.03%
Vaccination	Not vaccinated	137	3.07%	98	3.52%
	VAC 24	438	9.82%	269	9.65%
	VAC 34	2254	50.55%	1380	49.52%
	VAC 45	1061	23.79%	683	24.51%
	VAC Precon	169	3.79%	97	3.48%
	One respiratory vaccination	313	7.02%	205	7.36%
	Two or more respiratory vaccinations	87	1.95%	55	1.97%
Weaning	Weaned calves	1230	27.58%	780	27.99%
Age-and-source verified	Calves enrolled in program	674	15.12%	412	14.78%
Horns	Some, tipped and all horns	234	5.25%	182	6.53%
Breed	Cattle w/ ear	696	15.61%	511	18.34%
	English & English cross	432	9.69%	248	8.90%
	Continental & Continental cross	66	1.48%	50	1.79%
	English/Continental cross	1605	35.99%	1058	37.96%
	Black & black-white-faced	1294	29.02%	736	26.41%
	Predominantly Angus	270	6.06%	136	4.88%
	Predominantly Red Angus	96	2.15%	48	1.72%
Region of origin	West	891	19.98%	567	20.34%
	Rocky Mountain/North Central	2334	52.34%	1412	50.66%
	South Central	976	21.89%	636	22.82%
	Southeast	258	5.79%	172	6.17%

Table A.12 - 2006 to 2007 Coefficients Estimates for Hedonic Pricing Model

Characteristic	Variable description	Steers - 450 to 750 lbs.			Heifers - 400 to 700 lbs.		
		Observ. (lots)	Coefficient Estimates	P-Value (P>|t|)	Observ. (lots)	Coefficient Estimates	P-Value (P>|t|)
Intercept	Intercept	4459	289.9290	< 0.0001	2787	248.6726	< 0.0001
Lot size	Number of head	4459	0.0133	< 0.0001	2787	0.0230	< 0.0001
(Lot size)^2	Number of head squared	4459	-0.00001	0.2481	2787	-0.00002	0.0953
Weight	Average base weight of lot	4459	-0.4917	< 0.0001	2787	-0.4150	< 0.0001
(Weight)^2	Average base weight of lot squared	4459	0.00033	< 0.0001	2787	0.00030	< 0.0001
Frame	Small to medium	1935	-0.5866	0.0005	1252	-0.6790	0.0014
	Medium to medium-large mix	2003	Base		1235	Base	
	Medium-large to large	521	0.0382	0.8747	300	-0.0082	0.9787
Flesh	Light to light-medium	164	-0.3357	0.4432	128	-0.0980	0.8636
	Light-medium to medium mix	263	1.1014	0.0054	180	0.7241	0.1229
	Medium	3888	Base		2411	Base	
	Medium to medium-heavy mix to heavy	144	-1.2834	0.0005	68	-1.0071	0.0629
Weight variation	Even to fairly even	309	0.9869	0.0005	146	2.4804	< 0.0001
(uniformity)	Uneven	3995	Base		2521	Base	
	Very uneven	155	-0.4024	0.2977	120	-0.5389	0.2414
Implant	Not implanted	1466	Base		1106	Base	
	Natural eligible - Not implanted	1595	0.6863	0.0003	995	1.0296	< 0.0001
	Unknown or some implanted	117	-0.7204	0.1003	100	-0.8887	0.0921
	Implanted	1281	-0.1608	0.4139	586	0.0561	0.8261
Vaccination	Not vaccinated	137	Base		98	Base	
	VAC 24	438	1.6877	0.0006	269	2.8788	< 0.0001
	VAC 34	2254	3.6688	< 0.0001	1380	3.8696	< 0.0001
	VAC 45	1061	7.6097	< 0.0001	683	7.6151	< 0.0001
	VAC Precon	169	7.4729	< 0.0001	97	6.1672	< 0.0001
	One respiratory vaccination	313	1.3385	0.0108	205	1.9222	0.0062
	Two or more respiratory vaccinations	87	2.3300	0.0008	55	3.5854	< 0.0001
Age-and-source verifie	No	3785	Base		2375	Base	
	Yes	674	1.1875	0.0052	412	0.8098	0.0548
Horns	No horns	4225	Base		2605	Base	
	Some, tipped and all horns	234	0.6551	0.0711	182	-0.4669	0.3091
Breed	Cattle w/ Ear	696	Base		511	Base	
	English & English cross	432	4.0523	< 0.0001	248	3.0284	< 0.0001
	Continental & Continental cross	66	4.5587	< 0.0001	50	3.6958	< 0.0001
	English/Continental cross	1605	4.6867	< 0.0001	1058	3.6713	< 0.0001
	Black & black-white-faced	1294	6.3567	< 0.0001	736	5.2433	< 0.0001
	Predominantly Angus	270	6.7888	< 0.0001	136	6.0035	< 0.0001
	Predominantly Red Angus	96	7.0643	< 0.0001	48	11.8220	< 0.0001
Price variation	Feeder cattle futures price	4459	-0.0058	< 0.0001	2787	-0.0099	< 0.0001
Region of origin	West	891	-3.0380	< 0.0001	567	-2.6334	< 0.0001
	Rocky Mountain/North Central	2334	2.3049	< 0.0001	1412	1.9637	0.0004
	South Central	976	Base		636	Base	
	Southeast	258	-5.6507	< 0.0001	172	-7.5449	< 0.0001
Days to delivery	Days between sale and delivery date	4459	-0.0443	0.8762	2787	-0.0438	0.9059
Analysis of Variance and Homoskedasticity		***Adj. R^2 Value:*** *0.7527*			***Adj. R^2 Value:*** *0.6991*		
		Root MSE: *4.88275*			***Root MSE:*** *5.04999*		
		White Test Results: *P>Chi^2 < 0.0001*			***White Test Results:*** *P>Chi^2 < 0.0001*		
		DF = 504, Chi-Square = 678.89			*DF = 496, Chi-Square = 772.35*		

Table A.13 - 1996 to 2007 SLA Multi-Year Models F-test Results

F-test description	Model Years	Null Hypothesis Equation	Steers		Heifers	
			P-value	Test result	P-value	Test result
All breeds are equal	1996 to 1999	(15)	0.0009	Reject H_0	< 0.0001	Reject H_0
	2000 to 2003	(15)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2004 to 2005	(15)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2006 to 2007	(15)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2008 to 2009	(15)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
Angus = black-hide color	2000 to 2003	(16)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2004 to 2005	(16)	0.0137	Reject H_0	< 0.0001	Reject H_0
	2006 to 2007	(16)	0.1351	Fail to reject H_0	0.0852	Fail to reject H_0
	2008 to 2009	(16)	0.0068	Reject H_0	0.1092	Fail to reject H_0
All vaccination protocols are equal	1996 to 1999	(17)	< 0.0001	Reject H_0	0.0059	Reject H_0
	2000 to 2003	(17)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2004 to 2005	(17)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2006 to 2007	(17)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2008 to 2009	(17)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
VAC 24 and VAC 34 = One vaccination	1996 to 1999	(18)	< 0.0001	Reject H_0	0.0074	Reject H_0
VAC 24 = One vaccination	2000 to 2003	(18)	0.8205	Fail to reject H_0	0.0235	Reject H_0
	2004 to 2005	(18)	0.0862	Fail to reject H_0	0.0023	Reject H_0
	2006 to 2007	(18)	0.3547	Fail to reject H_0	0.0689	Reject H_0
	2008 to 2009	(18)	0.3019	Fail to reject H_0	0.1278	Fail to reject H_0
VAC 34 = One vaccination	2000 to 2003	(19)	0.4233	Fail to reject H_0	0.5142	Fail to reject H_0
	2004 to 2005	(19)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2006 to 2007	(19)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2008 to 2009	(19)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
VAC 34+ = Multiple vaccinations	2008 to 2009	(20)	0.0009	Reject H_0	0.1096	Fail to reject H_0
VAC 45 = Multiple vaccinations and weaning	1996 to 1999	(21)	< 0.0001	Reject H_0	0.0061	Reject H_0
	2000 to 2003	(21)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2004 to 2005	(21)	0.6876	Fail to reject H_0	0.2867	Fail to reject H_0
	2008 to 2009	(21)	0.0924	Fail to reject H_0	0.3105	Fail to reject H_0
SLA market efficiency	1996 to 1999	(22)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2000 to 2003	(22)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2004 to 2005	(22)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2006 to 2007	(22)	< 0.0001	Reject H_0	< 0.0001	Reject H_0
	2008 to 2009	(22)	< 0.0001	Reject H_0	< 0.0001	Reject H_0