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Effect of Marketing through Value Added and Video Sales on Feeder Cattle Prices

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EFFECT OF MARKETING THROUGH VALUE ADDED AND VIDEO SALES ON FEEDER CATTLE PRICES

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By

Amanda Jane Trotter

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ABSTRACT

Feeder cattle marketing opportunities for producers in Missouri continue to expand. Missouri ranks within the top ten U.S. States in beef cow inventory and is a major feeder calf exporter. Selecting the appropriate marketing opportunity can have a dramatic impact on the income of the cattle producer. Feeder cattle marketing opportunities include value-added program sales, video auctions, as well as the traditional live cattle auction. A long-term study comparing these marketing opportunities in a single livestock market in Missouri has not been conducted. The objective of this study is to analyze cattle characteristics that can influence market price in feeder cattle auctions and quantify any price premiums received for video or value-added over traditional sales. Data for this study was collected between March 2009 and December 2018 at Joplin Regional Stockyards, near Carthage, Missouri. Although cattle were sold through the same livestock auction different marketing strategies including value-added, video, or traditional feeder cattle auction were utilized. Market data from value-added, video, and traditional feeder sales over the study period included 521,586 lots encompassing 3,400,621 head of cattle. Analyzed descriptive factors that could affect the sale price of marketed cattle included sale date, weight class of lot, number of cattle per lot, gender, color/ breed influence, and auction type. Descriptive statistical analysis in Minitab 19 (Minitab Inc., State College, PA) was used to identify trends in the data. Multilinear regression analysis in Minitab 19 (Minitab Inc., State College, PA) was used to analyze the significance of categorical variables on the bid price. Analyzed categorical factors were found to be significant ($P < 0.05$). Overall value-added and video sales earned mean price premiums of $1 per cwt and $5.36 per cwt respectively in comparison to traditional auctions. This study confirms along with previous research that over time cattle sold through value-added and video sales will consistently sell for higher mean bid prices when compared to cattle at traditional auctions. Producers that take part in value-added management and marketing opportunities are likely to receive a higher price for their cattle than those sold through traditional auctions.

KEYWORDS: feeder cattle, cattle auction, value-added, video auction, marketing

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INTRODUCTION

Justification

Cattle and calves account for 19 percent of the market value of agricultural products sold according to the latest United States Census of Agriculture in 2017. Missouri ranks within the top ten states within the United States for beef cow inventory, beef replacement heifers, and beef cow operations. Missouri is also a major feeder calf exporter with 85 percent of calves sent to be finished in other Midwestern states. The cattle industry is important to overall Missouri farm income. Cattle and calves cash receipts totaled almost two billion dollars and ranked second among other Missouri agricultural commodities (USDA-NASS, 2017). Missouri beef cattle, livestock slaughter, and further processing industries provided 304 million dollars in state and local taxes and 459 million dollars in federal taxes during 2014. Direct contributions from these industries provided 45,088 jobs earning over one billion dollars in labor income in 2014 (Brown et al., 2016). Overall contributions from these industries totaled 72,566 jobs and about two billion dollars in labor income. In 2017 over three billion dollars in total value was added to Missouri's economy (USDA-NASS, 2017). Vertical coordination throughout the beef industry has created price signals for specific cattle traits at the ranch level. Various traits wanted by stockers, feedlots, packers, and consumers are signaled through market premiums to cow-calf producers. In Missouri alternative marketing ideas have been discussed and implemented by the cattle industry to promote growth and to ensure its economic potential. Alternative marketing includes the utilization of technology with video market sales and preconditioning with value-added sales that intend to increase cattle profitability. This research analyzes the market incentives available to cow-calf producers who utilize management and marketing through value-added production systems. The study will focus on the following objectives:

1) Analyze feeder cattle characteristics that influence market price in value-added, video, and traditional feeder cattle auctions
2) Quantify price premiums for marketing strategies of video or value-added over traditional sales

Based on the literature review it is predicted that calves raised and marketed in Southwest Missouri under more intensive management programs with verified health claims will receive a higher sale price than those of commodity calves which do not possess characteristics associated with more advanced herd management programs. It is hypothesized that producers that utilize video auctions and value-added sales marketing experience an increase in profit when compared to auction sales with no marketing. This study will be looking at the advantages for cow-calf producers that utilize value-added and video sales. Despite the findings of other studies that note financial advantages for feedlots and their increasing willingness to pay premiums for preconditioned cattle, many cow-calf producers are still unsure of the benefits of implementing these management practices.

LITERATURE REVIEW

Cattle Market History

Cattle were established in the United State through four waves of immigration, first introduced to the Americas by Columbus in 1493 and slowly spread throughout the continent. Spaniards first brought cattle from the West Indies to the coast of Florida. Later cattle were moved to the Southwest from Mexico including present-day New Mexico and Texas. Cattle were also transferred from French settlements in present-day Canada to the Great Lakes region. Additional cattle arrived in the American colonies along the Atlantic coast through the effort of Dutch, English, and Swedish migrants (Wagner et al., 2014). Many of these cattle imported by the English were of Spanish ancestry and were purchased in the West Indies. Imported cattle were initially used as draft animals with migrants from the Netherlands and Sweden primarily using cattle for dairy production (Sponenberg and Olson, 1992; Wagner et al., 2014).

Beef production was not considered a primary economic enterprise until the end of the eighteenth-century coinciding with the surplus of crops in the Ohio River Valley. In 1817 the first shipment of Ohio grain-fed steers reached New York (Wagner et al., 2014). Early grain and cattle production systems were simple. Cattle were often turned into the fields to harvest the crop themselves. Once fattened on surplus grain livestock walked to markets located near river systems as railroads were not established yet. The John Deere steel plow was invented in 1837 leading to increased crop production in the United States expanding the cattle feeding industry (Wagner et al., 2014). Cattle reached Missouri by 1840, at this time in the United States the largest population of cattle were located in the Southwest Texas rangelands. By 1855 there were 10 head of cattle in Texas for each person. However, inadequate storage and transportation meant that cattle were slaughtered primarily for hides and tallow with some meat sold as salt-packed beef. (Gracy, 2016).

In 1865, with the end of the Civil War and subsequent travel restrictions, the cattle business developed into an industry. Plentiful before the war, resilient Longhorn cattle multiplied to over 3 million in Texas during the conflict. Distribution of cattle was unequal across the United States, as a substantial shortage of meat was left in the warring states. Abundance of cattle in Texas offered opportunity for income, but only if the market could be reached (Gracy, 2016; Sponenberg and Olson, 1992). Without access to railroads or other means of transportation, cattle had to be walked hundreds of miles, by cattle drives, to the point of sale. One major route out of Texas for livestock, the Chisholm Trail, was used from 1867 to 1884 (Hoig, 1991). Although demand for meat was high, most trails were met with resistance. Longhorns brought with them "Texas Fever", a disease caused by microscopic protozoan, *Babesia bigemina*, that inhabits and destroys red blood cells. Devastating to naïve cattle, Longhorns had developed immunity to Texas Fever over generations. It was not until 1893 that ticks were discovered to be the transmitters causing many states, including Missouri, to close their borders to Texas cattle (Gracy, 2016; Sponenberg and Olson, 1992; Wagner et al., 2014).

Market information was disorganized, passing verbally to the drovers trailing cattle by those returning from the market. In order to be successful, the cattle industry needed more than a surplus of cattle; it required an advancement in sharing market information and other technologies. The first attempt to ship live cattle by rail occurred in 1852, but it was not widely utilized due to cost and limited access. In l860 the meat packing industry was revolutionized with the invention of the refrigerated railcar. Refrigeration allowed cattle slaughtered in the West to be kept fresh for buyers in the eastern meat markets. High demand from East coast consumers for "Western dressed beef" caused the number of cattle in the southwestern rangelands to double between 1880 and 1900 (Gracy, 2016).

The developing cattle industry brought increased competition, and a need for business marketing. In Abilene, Kansas entrepreneur Joseph McCoy built facilities on which to center a market; including a hotel, stockyard, office, and bank (Hoig, 1991). McCoy began using advertising campaigns in 1868 to better inform drovers of cattle destinations at the end of a driving season, and to build a reputation for reliability. Access to market information would lead the Treasury Department's Bureau of Statistics to issue its "Report in Regard to the Range and Ranch Cattle Business of the United States" in 1885 (Gracy, 2016). Setting the example for future market content, report topics included: yearly rainfall, temperature, grazing capacity, profitableness, breed improvement, quarantines, transportation of cattle, use of public land, and exportation of dressed beef. Need to exchange market information was also displayed by the National Cattle Growers' Convention first held in St. Louis, Missouri in 1884, and the Interstate Convention of Cattlemen in 1890 (Gracy, 2016; Wagner et al., 2014).

By the end of the nineteenth century trails were no longer being used for cattle transport (Hoig, 1991). As westward expansion continued, less space was available to graze large herds of Longhorns. With the invention of barbed wire in 1874 cattle were kept on enclosed ranches, and in smaller quantities. (Gracy, 2016). In the 1920s, due to the success of Texas Fever eradication programs, ranchers started to introduce European bulls for cross breeding with Longhorns. Markets began to favor different breeds of cattle that offered higher yields of meat and marbling (Sponenberg and Olson, 1992). Cattle markets continued to advance with developments in technology and animal health. Technological improvements, such as the increased availability of hybrid seed corn in the 1930s, and the development of deep well irrigation in the 1940s, have resulted in large increases in corn production over the past 150 years (Wagner et al., 2014). A resulting surplus of crops were produced and used for cattle feeding, expanding the feedlot industry (Sponenberg and Olson, 1992).

From simple beginnings, the modern beef industry has evolved into a complex system that is continually dependent upon technology. More recently with the help of technology a number of alternative marketing strategies have been developed that facilitate efficient transfer of market signals from the feedlot phase to the cow-calf production phase.

Market Cycle

Historically cattle markets experienced a relatively predictable 10-year cycle, as producers expand their cattle inventories in response to profits and contract their herd size in response to losses. During the last 15 years, outside forces have caused the cattle cycle to be more unpredictable (Petry, 2019). A cycle is a pattern that repeats itself regularly over a period of years and includes seasonal patterns and trends. A seasonal pattern is a regularly repeating market event that is completed once every twelve months and tends to occur near the same time each year. Examples of a seasonal pattern are the seasonal highs and lows in fed cattle or feeder cattle prices. Trends are long term directions within the market, with analysis of trends covering several years (Anderson et al., 2005). There are three parts of the cattle market cycle: cattle inventory, beef production, and cattle price. Cattle inventory cycles experience periods of increasing numbers called accumulation phases and periods of decreasing numbers called liquidation phases. Beef production cycles lag these inventory cycles by about one year because to liquidate cattle numbers more cattle have to be harvested. To accumulate cattle numbers, fewer cattle are harvested. Price cycles are typified by periods of increasing prices called increasing phases and decreasing prices called decreasing phases. Cattle price cycles are often the opposite of beef production cycles. Reproductive biology of cattle and weather have the most effect on the length of cattle cycles (Petry, 2019). While every cattle inventory cycle differs somewhat, patterns still occur across cycles. Each 10-year cattle inventory cycles typically experience 6 to 8-year accumulation phases and 3 to 4-year liquidation phases. Cattle cycles occur in large part because of the reproductive nature of cattle production (Anderson et al., 2005). A replacement heifer calf retained in the fall for breeding purposes will be bred the following summer and have a calf the next spring. The resulting calf will not reach market weight or be considered as part of beef production until the following year (Petry, 2019). Cow-calf producers respond to profitable calf prices by holding back more replacement heifers and not culling as many cows, thus the increase in cow numbers lead to more calves the next year. However, additional heifers held back for entry in the cow herd don't increase beef production for at least 3 years. Increase in cattle inventory and subsequently beef supplies lead to lower prices. Ultimately, prices decline below many cow-calf producers' break-even level which causes producers to start liquidating their herds. Herd liquidation will then continue until prices return to profitable levels (Anderson et al., 2005).

Timing and length of reproductive biology in cattle will not change given current technology. Therefore, cattle cycles likely will continue to occur, but they will be impacted more by worldwide economic and political conditions, and meat trade issues than in the past. The latest cattle market cycle has experienced unexpected and unpredictable events. Droughts in 2010 and 2012 lead to record high corn prices, poor pasture and range conditions, and continued beef herd liquidation in spite of record high prices for cattle. Unforeseen beef demand shocks such as competing livestock disease issues, federal government policies, global market, international trade policies, weather, and catastrophic events around the world quickly reverberate to prices paid for calves at auction markets throughout the United States. In 2014, prices for all market classes of cattle reached the cyclical high for the cattle cycle. Prices were supported by historically low cattle and beef supply that were coupled with beef herd building causing more heifers to be kept for breeding purposes, and the low beef cow harvest. In recent years another driver behind calf and yearling prices has been declining feed costs, a trend that mostly has run its course (Petry, 2019).

Cattle Marketing

Traditional auction marketing provides cattle producers with a central location where multiple buyers can bid on their cattle. Typical traditional auctions hold sales one or two days per week. Local producers haul cattle to the facility where they are bid upon by various types of buyers with the highest bidder purchasing the cattle. Assuming sufficient cattle numbers, competition among the buyers, and good information on animal value by both buyer and seller, this marketing method is efficient (Gillespie et al., 2004). Several disadvantages to traditional marketing exist, including: (1) Number of buyers bidding on a particular day may be small, reducing competition and leading to oligopsony power, therefore reducing the price received by the seller; (2) buyers whose primary goal is to fill a truck to capacity are unlikely to pay premium prices for top quality animals, again reducing the price received by the seller; (3) producers who have added "unobservable" value to animals, such as specific vaccinations or weaning practices, are unlikely to receive higher prices for these animals due to a lack of marketing, even though their expected performance and survivability in the next phase is greater; (4) transportation costs to and from the sale facility are incurred (Gillespie et al., 2004); (5) significant "shrinkage" is likely as the animal is hauled to and kept at the conventional auction prior to selling. Shrinkage is the decrease in the live weight of an animal due to loss of urine and feces, or tissue loss as a result of fasting. Thus, revenue declines with animal weight (Schwartzkopf-Genswein et al., 2016). Alternatives marketing to traditional auctions exist to account for the above disadvantages, including video and special sale auctions.

Commingling

During traditional feeder cattle sales, to combat disadvantages (2) and (3) stated above, livestock auctions may sort or commingle cattle from multiple producers into larger lots. Amount of cattle in one group or truckload are commonly referred to as a "load lot". While weights vary, a load lot is commonly described as a certain weight of animals needed to fill a transfer trailer, typically about 50,000 pounds (Hopkins et al., 2015). Selling cattle in load lots aims to capture extra value by bundling the cattle. Loads are usually sorted ahead of time and lots will vary greatly. Value of the load lot is not always dependent on the type of cattle present, but in the consistency of the cattle in the lot (Hopkins et al., 2015).

Commingling load lots are based on weight, shape, color, and class of cattle. Previous research has illustrated the influence producers can have on market prices by knowingly selecting these certain characteristics. Significant price differences are present depending on breed, grade, gender, and weight; reinforcing the significance of these characteristics to producers involved with commingled sales (Mintert et al., 1990; Schroeder et al., 1988).

Larger, uniform groups are attractive to more buyers and will therefore bring a premium price when compared to cattle sold in drafts of less than five head. Seventy-nine percent of all beef cow operations in the U. S. have less than ninety-nine head (Davis, 2000). Meaning only eight percent of all U. S. cow-calf operations offer a truckload lot. Commingled sales provide smaller operations the opportunity to market their cattle to buyers that cannot justify the expense of only shipping the few head of one producer (Mintert et al., 1990, Schroeder et al., 1988). Such a sale is also beneficial to feedlots as it provides an opportunity to purchase large lots of cattle that will gain at a similar rate. Weight variation was a statistically significant price determinant in feeder calf markets in studies by Blank et al. (2006) and Schroeder et al. (1988), and Harborth et al. (2010). Price premiums for increased weight uniformity can be expected as 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.

A role of many feeder cattle buyers is to accumulate small sale lots of feeder cattle with specific traits into larger, often truckload size groups. Stocker producers and cattle feedlots want larger groups preferably in truckload size groups of calves for more efficient shipping and to fill preestablished pasture and pen sizes. Therefore, the buying task is made easier if feeder cattle are sold in larger sale lots (Avent et al., 2004). Previous research has shown that uniform lots of cattle sold in sizes of 45 to 65 head have yielded premiums in dollars per hundredweight, compared to cattle sold in regular auctions in single or small lots (Mintert et al., 1990). Another study found that as lot size increased so did the price per hundred weight. The prices paid for cattle were highest for lot sizes approaching truckload total weights. However, as lot sizes exceeded truckload sizes, prices leveled off and even decreased as there were fewer buyers available to bid on larger lot sizes (Harborth et al., 2010).

Advantages for buyers can be mixed when disease risk is considered. Cattle buyers prefer to purchase larger lot sizes as the incidence of health problems decrease with non-mixed cattle, convenience of large purchases, and less transportation costs (Harborth et al., 2010).

Commingled calves typically come from small lots of unknown genetic merit, and medical history. Most commingled calves have not been preconditioned and will be "weaned on the truck". Meaning the first-time calves are separated from the cow and milk is removed from the diet during transport. As will be discussed later combined stress of transport increases the risk of disease in the already high-risk calves that come from multiple backgrounds (Wolfger et al., 2015).

Video Sales

Video marketing was first introduced in 1987 with the use of satellite, offering a different way for load lots of cattle to be marketed. Obvious differences exist between video and traditional auction markets. Video marketing records the auction for online access and does not require the cattle to be present at the sale barn (Zimmerman et al., 2012). Distinctions between auction types are important when analyzing results of video market pricing.

Advantages to video sales in relation to traditional auctions are as follows: (1) Buyers worldwide can bid on animals as long as they have access to the internet, therefore increasing competition (Bailey et al., 1991); (2) buyers who purchase via video auction are typically interested in specific types of cattle (e.g. weight, color, class) and are more likely to pay premium prices for specific traits (Bailey and Peterson, 1991); (3) cattle remain on the ranch before sale, potentially reducing travel costs associated with traveling to the sale barn for producers, (5) reduces cattle shrinkage, stress, and health concerns related to commingling herds from different sources (Mintert et al., 1990; Zimmerman et al., 2012); (6) online information provided by video auctions are in written form and can reduce the risk of asymmetric information by creating a greater level of transparency than what is available at traditional auctions (Chymis, 2004; Zimmerman, et al., 2012).

A major disadvantage is the high quantity of cattle needed to effectively use video auctions, limiting this option to larger producers or alliances of smaller producers. However, the large number of cattle tend to attract buyers that are already searching for larger quantities of consistent quality animals. If these buyers' preferences are based upon feedlot operator preferences then pricing efficiency has been gained (Gillespie, 2004). Another potential disadvantage to video auctions if not managed correctly is price slide. At the time of the video auction producers are expected to accurately estimate what cattle will weigh at delivery, sometimes months in advance. Thus "price slide" is used as a mechanism to reduce risk of an inaccurate seller's estimate of delivery weights. Price slide can be an important merchandising technique for selling cattle in a video sale format as it conveys how much confidence sellers have in estimated delivery weights. Slide is the adjustment of the final sale price to accommodate a variance in weight. Value can be added or subtracted from the quoted selling price, depending upon stated weight range at "point of sale". Live weight and the amount of the slide are inversely related. Slide is an adjustment to price that is typically applied when the average per head of cattle delivered weight exceeds a specified limit that is outlined in the contract. Slide can be used as a marketing tool for the seller. An accurate slide that reflects current seller and market conditions can be beneficial when marketing cattle. Buyers recognize that a seller who places a higher slide with a smaller weight variance has more confidence in delivery weights than a seller who places a smaller slide with a larger weight variance (Zimmerman et al., 2012).

Value-added Sales

To appeal to feedlot operators, cow-calf producers have implemented alternative marketing practices such as value-added sales. Special sales, as they are also called, give producers the opportunity to market their cattle when certain value-added practices have been followed. Practices such as: pre-weaning, health programs, optional feeding programs, and individual animal identification. Many preconditioning protocols exist with most programs requiring cattle to be dehorned, bulls castrated, and heifers guaranteed "open", meaning they are not pregnant (Zimmerman et al., 2012).

Polled feeder calves are those born without horns. Polled cattle normally receive a price premium when compared to horned calves and dehorned calves. Discounts were applied to sale lots with horns in studies by Sartwelle et al. (1996), Bailey et al. (1993), Lambert et al. (1989) and Schroeder et al. (1988). Buyers prefer polled animals since they are easier to manage and present a lower risk for carcass bruises than horned animals, which is supported by a 1995 Beef Quality Audit that found a significant increase in carcass bruise damage compared with the 1991 Beef Quality Audit. Most preconditioning programs require dehorning calves (Smith et al., 2000). Therefore, to the extent producers' market preconditioned, dehorned calves versus marketing horned calves, higher prices can be expected from the dehorning requirement in preconditioning programs (Moony et al., 2019). One study found a $2 per cwt discounts for calves with horns (Cleere and Boleman, 2005). Another study found that the 85 percent of feeder cattle were polled. Polled feeder cattle sold for $118.57 ± 0.05, and horned feeder cattle sold for $114.87 ± 0.14 ($P < 0.001$) (Castro et al., 1998).

Breed and color influence have been shown in recent studies by Harborth et al. (2010), King et al. (2006), McCabe et al. (2019), and Smith et al. (2000) to have a statistically significant influence on calf sale price. Black cattle that can be marketed as Angus traditionally earn more since there is a higher demand from consumers for that breed. Buyers also look at cattle breeds as an indicator for expected growth and carcass quality.

Previous research consistently shows significant feeder cattle price differences among steers, heifers, and bulls. Most preconditioning programs require castrating bull calves, leading to higher prices for the castration requirement in preconditioning programs (Avent et al., 2004). Buyers typically pay higher prices for steers when compared with heifers and bulls due to expected feedlot performance differences. A Texas study found prices were significantly higher for steers than for bull calves. Heifer prices were consistently below steer prices, averaging $0.15 per pound discount (Russell, 2015). Quantifying the revenue gains associated with castration and growth implanting, the study found the benefit of castration is relatively low for calves lighter than 500 pounds but relatively high for calves sold at more than 500 pounds. Bull and steer prices from 350 to 500 pounds differed by an average of $0.06 per pound, or $25 per head. Other factors such as the presence of horns and breed type are likely more important in determining the prices for calves weighing less than 500 pounds. Above 500 pounds, prices for bulls begin to fall even more in relation to steer prices. Bull prices continue to fall ending up below the predicted heifer price at 700 and 750 pounds. Per-head price difference between steers and bulls' averages $81 for calves between 550 and 750 pounds, $30 for 550-pound calves, and $154 for 750-pound calves. Therefore, showing a financial benefit to castration and implantation. Implanting was included in the Texas study to consider that a steer that has been castrated but not implanted will not reach as heavy a weight at weaning as an intact bull. Premiums for steers represent part of the feedlot's reduced risk of death loss. Male cattle castrated at higher weights have an increased risk of death loss from infection and blood loss. (Russell, 2015). Another study found that steers are on average worth $3 to $6 more per cwt, depending on weight. Discounts for bull calves increase an animal's weight increases to allow for shrinkage and possible death loss from castration. (Cleere and Boleman, 2005).

Preconditioning programs aim to reduce the likelihood animals experience sickness or poor health during and after sale (Hopkins et. al, 2015). One benefit to preconditioning cattle is the improved health or perceived improved health of the animals (Avent et al., 2004). Value-added sales appeal to the grower and feedlot industries that prefer and will therefore pay a premium for preconditioned cattle (Mintert et al., 1990; Zimmerman et al., 2012). Preconditioning occurs over a period of time prior to sale in which a cow-calf producer will work to train and build the health status of a calf that is weaned, meaning the calf is no longer consuming milk and is on an adult diet (McNeill et al., 1996). Timing for these programs, typically 45 days prior to sale, are based upon results observed in the Texas A&M Ranch to Rail program that found weaning 45 days before sale boosted performance in post-weaning production phases (Cleere, 2005; McNeill, 2001).

Another study compared the health status of 2,000 calves weaned less than 30 days to calves weaned longer than 30 days. Over nine years, the study found calves sent to a feedlot less than 30 days after weaning had a higher incidence of bovine respiratory disease of 28 percent compared to calves weaned longer than 30 days at 13 percent. Calves that required three or more treatments were significantly different six percent versus one percent in favor of calves that had been weaned more than 30 days. Cattle weaned less than 30 days were not different in health attributes than those that were weaned on the way to the feedlot (Faber et al., 2000). During preconditioning calves are vaccinated and trained to eat from a bunk, or "bunk broke" in order to become acclimated to a prepared diet similarly used in feedlots.

Determining the return on preconditioned calves involves the interaction of many factors. Some costs associated with preconditioning programs include: labor, vaccinations, death loss, additional feed costs, and interest expenses on borrowed money. Additional cost factors are the seasonal patterns of the cattle market, and the price slide on increased calf weights (Mintert et al., 1990). Potential monetary gain associated with preconditioning is typically the added premiums at sale (Blank et al., 2006). Previous research has been conducted on the market value for various traits of feeder cattle. Studies consistently find that preconditioning affects feeder calf traits such as weight, condition, horns, gender, and health, but that preconditioning does not directly affect other traits such as breed, frame size, and muscle thickness (Avent et al., 2004).

Research indicates feeder cattle prices decline as feeder cattle weight increases, how much depends on market conditions. Preconditioning calves results in marketing heavier animals in comparison to marketing calves at weaning. Producers sell more cattle per pound after preconditioning, but the weight effect alone leads to lower prices for preconditioned calves. However, lower prices may be offset by the seasonal price component associated with most preconditioning programs. Preconditioning programs are frequently used with spring calving programs. Instead of selling calves at weaning in October calves would be marketed 45 days later during November or December. Typical seasonal price pattern for feeder calves throughout the U.S. involves a higher selling price for feeder cattle during November and December than October (Peel and Meyer, 2002). Preconditioning may enable cow-calf producers to capitalize on the normal seasonal sale price pattern for feeder calves.

Condition of feeder cattle has also been found to affect feeder cattle prices, but the degree of price differences varies by time of study and market conditions (Smith et al., 2000). Condition is not looked at in this study but is worth noting. One disagreement among studies is that thin cattle may be discounted, especially if the animal's thin condition is due to poor health or muscling. However, if associated with poor nutrition thin cattle could potentially receive a price premium because buyers expect compensatory gains after improving the nutritional level. Overweight cattle are known as "fleshy cattle" and are usually discounted as a recognition by buyers that no compensatory gains are likely. Fleshy cattle may be preferred in some cases as long as the degree of fleshiness is slight and is associated with health or thriftiness of the animals. Some buyers may associate the increased fleshiness with higher nutrition and health and may on occasion pay a price premium for preconditioned calves (Avent et al., 2004).

Multiple studies support that healthier appearing and preconditioned calves receive premiums over non-preconditioned calves. Health is one of the most important stocker and feeder cattle traits (Lalman and Smith, 2001). Preconditioned calves are expected to be healthier, less stressed, and have a stronger immune system than those sold at time of weaning. Cow-calf producers should expect a price premium for preconditioned calves due to animals assumed improved health. Of all feeder cattle characteristics, studies have found that health related attributes often have the most effect on price. Unhealthy calf traits generally translate into severe price discounts (Avent et al., 2004).

In a study conducted over 15 years from Superior Livestock auction sales, beef calves in certified health programs sold for significantly higher prices compared with sale prices for similar calves that were not in a certified program, had not been administered a vaccine against respiratory tract viruses at some time point prior to shipment from the farm or ranch of origin, and had not been weaned. Sale prices for calves in the most intensive health program were also found to be significantly higher than prices for calves in basic health programs in all years of the study (Seeger et al., 2011). This agreed with the findings of a former study that looked at the same auction (King et al., 2006). Another study found that value-added programs were most preferred in weaned calves with at least two rounds of respiratory vaccinations when compared to non-vaccinated and non-weaned calves and resulted in premiums of $2 to $4 per cwt. for steers and $1 to $2 per cwt. for heifers. Booster vaccinations required for the health program would likely provide calves with an enhanced degree of immunity against bovine respiratory disease (BRD) and clostridial pathogens, and the 45-day period after weaning is more likely to prepare calves for the stresses associated with transportation and adaptation to a new environment. (Zimmerman et al., 2012). Research primarily focuses on the preconditioning bonus, but one 11-year study looked at factors under the direct control of the producer, such as health, marketing options, and growth. The preconditioning enterprise was profitable in each year of the study. Returns to preconditioning were primarily due to added weight sold of 63 percent of return to preconditioning with the preconditioning health sales price advantage adding the remaining 37 percent (Hilton and Olynk, 2011).

Studies support the importance health makes to stocker, feedlot, carcass performance, and profitability. Preconditioning increases feedlot and carcass performance while reducing feedlot morbidity and mortality rates and lowering medicine costs (Lalman and Smith, 2001). A study by Avent asked managers of Texas Cattle Feeders Association's (TCFA) member feedlots to estimate performance differences between preconditioned calves and non-preconditioned calves. Managers perceived advantages in several performance categories after preconditioning cattle. Perceived advantages are: reduced morbidity, reduced mortality, increased average daily gains, improved feed conversion, higher percentage of Choice grade carcasses, and fewer nonconforming or severely discounted carcasses frequently referred to as "outs" (Avent, 2002).

Third-party certification of preconditioning for value-added sales is another marketing tool for producers, as it is valuable in enhancing credibility (Bulut and Lawrence, 2007). Age and source verified calves (ASV) receive premiums in auction sales (Yeboha and Lawrence, 2000). Some certification processes also screen for cattle that have any type of health problem. Cattle with health issues are then sorted out and not certified or marketed with certified calves. 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 (Kellom et al., 2008; King et al., 2006, Seeger et al., 2008). A study found that there is value to additional management practices for small lots of cattle, and also analyzed the value of the certification program. Producers marketing lightweight cattle received the greatest value from the certification. Cattle in the 350 pounds category provided the largest benefit of the certification of +$2.81, while larger animals in the 750 pounds category had a negative premium of -$0.09 (Williams et al., 2012).

Reputation of preconditioning programs were also found to have an impact. Buyers of feeder cattle pay premiums for what they feel is the quality of the cattle, given the confidence they have that producers treated the animals according to the specified program (Yeboha and Lawrence, 2000). In a study discusses earlier, Texas Cattle Feeders Association's (TCFA) managers estimated that preconditioned calves were worth $5.25 per cwt. more on average than non-preconditioned calves. Managers' perceived worth of preconditioned cattle was often higher than another research reported. A possible reason for the difference may be the reputation and perceived integrity of existing preconditioning programs (Avent et al., 2004). A similar study looked to determine how much feedlot operators' value certified health preconditioning programs across the United States. The study found feedlots desired cattle that have been weaned and preconditioned, preferably with an identified health program that is certified by a credible third party, like the USDA. Cattle that are raised through identified health programs were expected by feedlot operators to experience greater feed efficiency in the feedlot and therefore have additional value to the feedlot relative to cattle that are not weaned and have not gone through a certified health program. The results indicated weaning alone was worth at least $5 per cwt and when included an identified health program, the two can be worth $7 to $12 per cwt to the feedlot. If the preconditioned health program is USDA certified, feedlots on average value certification alone to be worth at least $2 per cwt (Schumacher et al., 2011). Cattle feeders might pay a premium more closely related to the expected performance difference if there was higher perceived assurance and confidence that cow-calf producers followed the preconditioning protocol therefore, resulting in actual expected performance differences. Without a perceived integrity assurance, cattle feeders will bear a portion of the risk and will respond by bidding less than the "true" or estimated value difference (Avent et al., 2004).

Preconditioning

As discussed earlier, valve-added sales are a marketing tool utilized by livestock auctions. Value-added sales are designed to appeal to the grower and feedlot industries that will pay a premium price for healthy, preconditioned cattle (Mintert et al., 1990; Zimmerman et al., 2012). Value-added programs vary and come from several origins such as the following: state veterinary medical association (e.g. Missouri Stocker Feeder Quality Assurance Program®), state extension programs (e.g. Texas Cooperative Extension's TexVac45®), animal health companies (e.g. SelectVAC® by Zoetis™), agricultural cooperatives (e.g. MFA Health Track® by MFA Incorporated™), and cattle marketing organizations (e.g. Integrity Beef Alliance® with Superior Livestock Auction™; JRS Wean-Vac 45 Sourced® from Joplin Regional

Stockyards™). Value-added programs differ in their focuses with some programs focusing more on vaccinations, while some involve nutrition, and others require verification on the source of the cattle. Value-added sales require producers to follow specific health guidelines, designed by the auction or organization, in order to enroll cattle in the program. Health programs aim to prevent the top health risks in cattle, and therefore require vaccines that prevent against Bovine Respiratory Disease Complex (BRD), Blackleg, and require de-wormer for parasite control (Gorden and Plummer, 2010; Mintert et al., 1990; Zimmerman et al., 2012). While previous studies note the health and financial advantages for feedlot producers, and their increasing willingness to pay premiums for preconditioned cattle, some cow-calf producers are still unsure of the benefits of value-added cattle.

As technology advances there is an ever-increasing push from consumers for information regarding their food source. The market has evolved its focus from ensuring that minimum public health standards are adhered, to verifying that the product is true to its description, to ensuring that the product also meets consumer expectations relating to eating enjoyment, and now to social, moral and ethical quality aspects (Henchion et al., 2017). Buyers for feedlots must look at their specific needs to evaluate the economics of purchasing cattle through value-added auctions. Most of the extra cost associated with calves from conventional auctions is labor. Producers must put a value on the time required to castrate and dehorn calves and to observe and treat calves for BRD. For producers who feed cattle on a fulltime basis and spend more time with their animals, calves obtained through conventional auctions may be the most profitable choice. Value-added sales provide extra benefits to buyers in terms of uniform lots, large numbers of calves offered for purchase, and efficient movement of calves through the auction ring. These features aid producers in putting together uniform groups for the feedlot and allow for useful time management (Macartney et al., 2003).

Preconditioning and Immunology

The role of preconditioning cattle is to reduce stress and increase immunity to costly diseases. Immunity is the body`s ability to tolerate the presence of material indigenous to the body, and to eliminate foreign material. This discriminatory ability provides protection from infectious disease, since most microbes are identified as foreign by the immune system (Woolums, 2019). Immunity to a microbe is usually indicated by the presence of antibody to that organism. There are two mechanisms for acquiring immunity, active and passive. Passive immunity is protection by products produced by an animal and transferred to another animal, either through colostrum or injection. By consuming colostrum, the cow's first milk after calving, calves receive passive immunity through shared antibodies. About 5 to 6 weeks before calving immunoglobulins from the cow's serum are concentrated into the colostrum. These immunoglobulins molecules are too large to pass though the placenta directly to the fetus therefore, colostrum must be consumed by the calf. Timing of vaccination related to colostrum production in the cow is critical. It takes 10 to 14 days after the second vaccination for heifers or annual booster vaccination for cows to stimulate peak antibodies therefore, vaccines are administered to the cow six weeks before calving. Passive immunity often provides effective protection however, this protection disappears over the time of a few weeks or months.

Active immunity is stimulation of the immune system to produce antigen-specific humoral (antibody) and cellular immunity (Plotkin, 2008). Unlike passive immunity which is temporary, active immunity usually lasts for a lifetime. An animal may acquire active immunity by surviving infection of the disease-causing form of the organism (Wenzel, 2015). Following exposure of the immune system to an antigen, memory B cells continue to circulate in the blood and bone marrow for many years. Upon re-exposure to an antigen, memory cells will begin to replicate and rapidly produce antibodies to reestablish protection causing immunologic memory which is the persistent protection after the infection. Another way to produce active immunity is through vaccinations that interact with the immune system typically producing an immune response similar to that produced by the natural infection, but they do not subject the recipient of the vaccine to the disease and its potential complications. Most vaccines produce immunologic memory similar to that acquired from having the natural disease. The immune system is a complex system of interacting cells whose primary purpose is to identify foreign substances referred to as antigens. Antigens can be either modified live viruses and bacteria or inactivated. The immune system develops a defense against the antigen. This defense is known as the immune response and usually involves the production of protein molecules by B lymphocytes, called antibodies or immunoglobulins, and of specific cells, including T-lymphocytes also known as cell-mediated immunity whose purpose is to facilitate the elimination of foreign substances. The most effective immune responses are generally produced in response to a live antigen. However, an antigen does not necessarily have to be alive as occurs with infection with a virus or bacterium, to produce an immune response (Plotkin, 2008).

The purpose of a vaccination program is to raise the level of resistance to viruses and other pathogens before a disease challenge occurs. Vaccination does not equal immunization. Nutrition, vitamin and mineral balance, stress, and overall health of the animal influence the immune response to vaccinations. Stressors should be avoided at vaccination time to maintain the integrity of the immune system. Procedures like castration, dehorning, weaning, and movement have to be considered as stressors in cattle and all have the potential to temporarily diminish immune system functioning. Systemic vaccinations should be avoided during high-stress times because of these diminished responses and because vaccination at such times may even have undesired effects (Zavy et al., 1992). Typically, the first time an animal encounters a disease-causing agent known as a pathogen, the immune system cannot respond quickly enough to prevent disease. Vaccines work by exposing the immune system to antigens from a specific pathogen, tricking the body into thinking is has encountered the actual pathogen. Exposure to an antigen stimulates an immune response, which creates memory cells for that pathogen, without causing the negative effects of an actual first infection (Wenzel, 2015). To vaccinate an animal antigenic material is administered to stimulate the immune system to be able to fight off disease causing organisms that may invade the animal in ways discussed above before significant natural exposure. Vaccines contain bacteria, viruses or a combination of both. To prevent the vaccine from causing disease when it is administered to an animal, the vaccine manufacturers will alter the organisms during the manufacturing process. Commercially available vaccines come in two main forms: killed and modified live. Killed or inactivated vaccines contain viruses or bacteria that are no longer alive, preventing them from causing the disease in the animal, but are still able to stimulate the immune system. Modified live vaccines (MLV) are live viruses or bacterium that still have the ability to replicate but have been attenuated or altered in such a way that they have lost disease-causing ability, or are administered by a route that prevents them from causing clinical disease (Cleere, 2005).

Common examples of killed vaccines are blackleg and leptospirosis, which are bacterial diseases. Killed vaccines may also contain viruses such as Infectious Bovine Rhinotracheitis (IBR), Bovine Viral Diarrhea Virus (BVD), Bovine Respiratory Syncytial Virus (BRSV) and

Parainfluenza 3 (PI3). Modified live vaccines may have a killed component to them, such as the five strains of a killed leptospirosis contained along with IBR, BVD, BRSV and PI3. Advantages of MLV are that they provide quicker protection, better protection, and longer lasting protection against viral diseases, when compared to killed vaccines. One dose of MLV may also elicit a protective immune response in an animal that has never been vaccinated before, whereas a killed vaccine will require a second dose 3 to 4 weeks later. Even though one dose of MLV may be adequate in some instances, it is generally recommended that a second dose of the vaccine be administered 3 to 4 weeks later to ensure a greater percentage of the herd is immunized. As mentioned earlier memory cells have varying lifespans making the timing of vaccinations critical. A second vaccination or booster creates an immune response of longer duration due to the higher concentration and therefore increase in effectiveness of memory cells with repeated exposure to an antigen (Figure 1). Repeated exposure from a booster vaccination will stimulate the immune system to react to an antigen so antibodies are present in the animal at a level that is highly protective if exposure to the actual pathogen occurs. Many inactivated vaccines and some modified live BRSV vaccines require a booster before protection is complete. The first time an inactivated vaccine is administered, the primary response occurs. This response is not very strong, short-lived, and predominantly composed of Immunoglobulin M antibodies. Immunoglobulin M (IgM) is the first antibody to appear in response to initial exposure to an antigen and is found mainly in the blood and lymph fluid. The response seen after a booster vaccination is called the secondary or anamnestic response. This response is much stronger, of longer duration, and is primarily composed of Immunoglobulin G antibodies. Immunoglobulin G (IgG), the most abundant type of antibody, is found in all body fluids and protects against bacterial and viral infections. If the booster is given too early, the anamnestic response does not occur, and if too much time elapses before the booster is given, it acts as an initial dose, not as a booster (Tizard, 1992). Once properly immunized, animals administered one dose annually of either the killed or modified live vaccine is usually sufficient to “booster” immunity. However, in cases where pathogen exposure exceeds the animal’s protective level disease may still occur. (Wenzel, 2015). Possible disadvantage of the MLV is the precautions they have associated with the miscarriages, some are not labeled for use in pregnant cows, or calves nursing pregnant cows (Cleere, 2005). Some brands of MLV vaccines are approved for use in pregnant cows and calves nursing pregnant cows, provided the cow was vaccinated in the past 12 months while “open” or not pregnant.

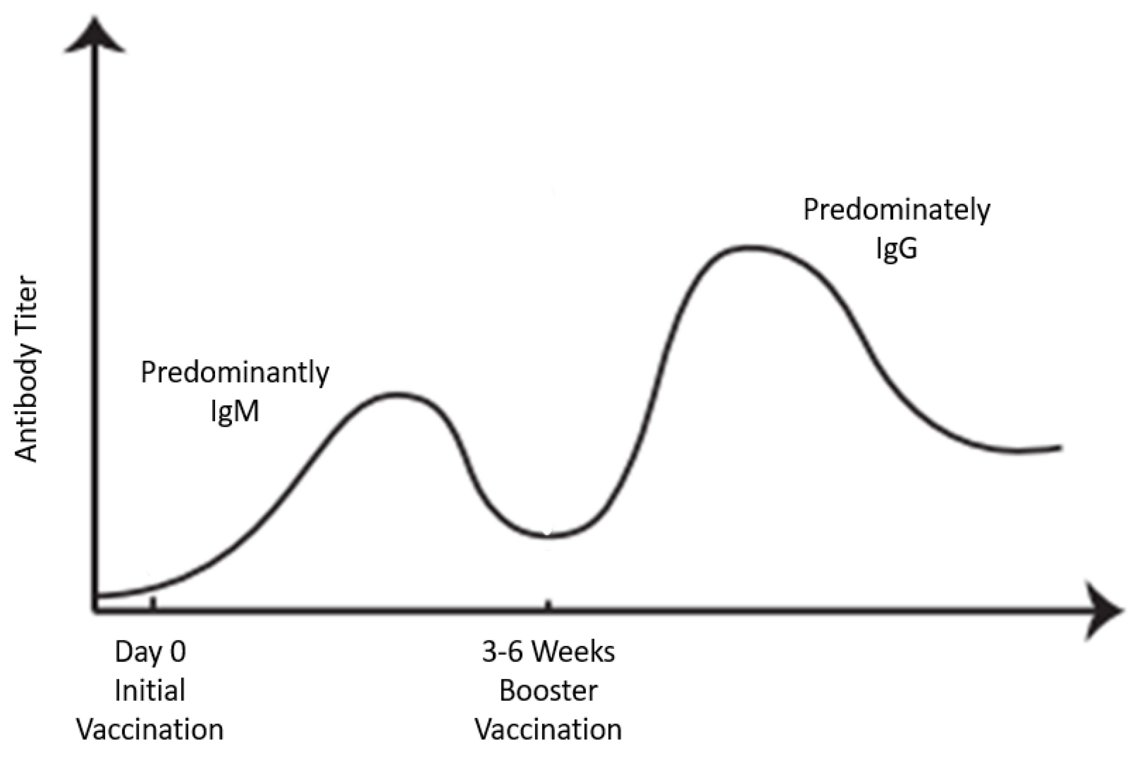

Figure 1. Change in serum antibody concentration when initial vaccination is followed by a secondary (booster) vaccination. Adapted from Wenzel1, 2015.

Stress Effects on Immune Response

Current marketing industry layout causes stress on the animals. According to the Humane Slaughter Association stress is defined as situations that release emergency signals for survival. Animals can experience three types of stress: physical stress due to fatigue or injury, physiological due to hunger, thirst, or temperature control, and behavioral due to surrounding environment, unfamiliar people, animals, and sounds (HSA, 2019). Cattle transported over long distances are exposed to factors which caused stress or stressors such as: diesel fumes, fluctuating weather conditions, dehydration, starvation, and exhaustion. Once at the sale barn, feeder calves comingle with other cattle of unknown disease and vaccination status. At the feedlot, stressors include processing, additional commingling, dust pollution, and introduction to new feed and water (Griffin et al., 2010). Transportation and cold stressors were found to cause a transient elevation of plasma cortisol levels along with a decrease in serum complement activity in calves acquired through sale barns. These factors may often increase host susceptibility to BRD (Rice, 2013). Stressors have additive effects, thus when several stressors impinge upon the animal at the same time the resulting stress response will be much higher than if the animal was exposed to one stressor only. Therefore, circumstances such as weaning and transport can be particularly difficult for the animals. Stress is classified as chronic or acute depending on the duration of time an animal is subjected to a particular stress. Acute stress arises when an animal experiences a stressor for a short period of time and can be associated with the fight or flight response. Acute stress is involved in preparing the immune system to stimulate adaptation for a short period of time. Chronic stress is a result of long-term exposure to a stressor resulting in a prolonged disruption to the homeostatic state. The stress response shifts from preparing the immune system to suppressing the immune system. The transition between acute and chronic stress is dependent on the intensity of the psychological perception of the animal to a particular stressor (Brown and Vosloo, 2017). Stress can suppress immune function however, the ways in which chronic stress suppresses the immune system are highly specific, and only some types of defense against disease are affected. When stress response involves release of glucocorticoids or catecholamines, the capacity of cellular immune mechanisms is reduced, meaning that some disorders are more likely to be precipitated by chronic stress than others such as respiratory infectious diseases. Transport stress has been shown to increase pneumonia caused by bovine herpes virus-1 (BHV-1) in calves, pneumonia caused by Pasteurella, and mortality in calves. Susceptibility to other diseases can also be increased as a result of situations which are likely to be stressful. Stress occurs in conditions where an environmental demand exceeds the regulatory capacity of the organism, in particular when such conditions include unpredictability and uncontrollability. Two main elements of the stress response in the body are the hypothalamic-pituitary-adrenal axis (HPA) and sympatho-adrenomedullary system (SAM) system with plasma levels of glucocorticoids widely used as measures of stress. When SAM is activated in response to short-term or acute stress and is unable to rectify a stressful event the HPA axis is activated (Figure 2), which is involved in resolving long-term, chronic stress. Current research on stress biology has addressed the role of the brain. Several areas of the brain are involved in the organization of responses to aversive or threatening stimuli, and these areas interact extensively. Neurons in the hypothalamus are sensitive to internal physicochemical stimuli and to external physical and psychosocial stimuli. Stress response is mediated by the corticotropin releasing factor (CRF) that is secreted mainly by the paraventricular nucleus of the hypothalamus. Adrenocorticotropic hormone (ACTH) is a hormone produced in the anterior, or front, pituitary gland in the brain. The function of ACTH is to regulate levels of the steroid hormone cortisol, which released from the adrenal gland (Manteca et al., 2013).

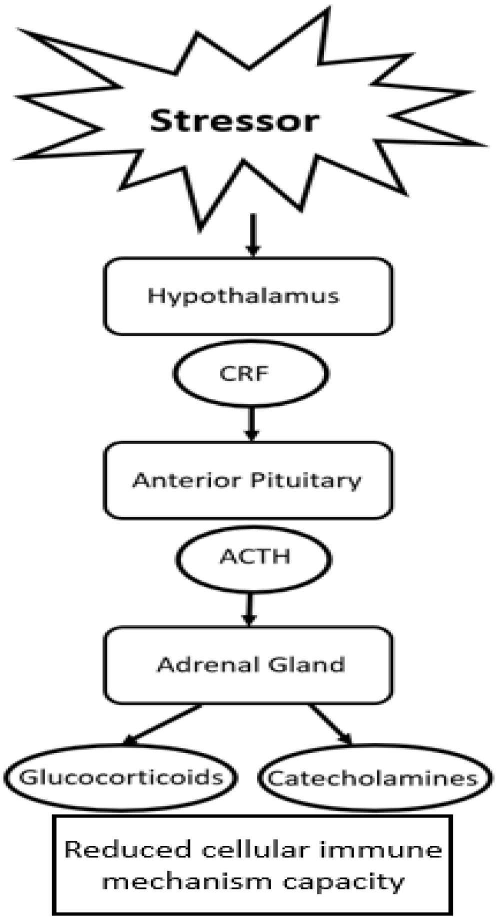

Figure 2. Pathways of stress response in cattle. Adapted from Manteca et al., 2013.

Cortisol, a primary glucocorticoid in cattle, is released from the adrenal cortex and distributed via the circulatory system to various target tissues, organs, or systems in the body. In order for glucocorticoids to be transported via blood in the circulatory system, carrier proteins must be present. Albumin is the main cortisol binding globulin. The severity of the effect that glucocorticoids exert on the target organs or tissues or systems is dependent upon the following factors: the amount of hormone that is secreted, duration of hormone secretion, peripheral blood concentration and cortisol binding globulins, abundance of glucocorticoid receptors in target tissues, tissue on which they exert an effect and extent of the breakdown of glucocorticoid metabolites. Since glucocorticoids are the final effectors of the HPA axis, they play a vital role in the control of homeostasis and the basal cortisol concentrations.

Glucocorticoids also play a role in the mechanism of negative feedback. When the hypothalamus and anterior pituitary detect high concentrations of cortisol, the release of vasopressin (VP) and CRF from the hypothalamus and ACTH from the anterior pituitary is inhibited, resulting in inhibition of the synthesis of cortisol from the adrenal cortex and termination of the stress response. Although the HPA axis is advantageous in the restoration of the homeostasis to its normal state, failure to end the stress response can result in the overstimulation and dysregulation of the homeostatic system, resulting in a phenomenon known as allostatic load or overload. Termination failure may be a result of stimulation and activation of an inadequate response to the perceived stressor, or continuous habituation to the stimulus is not attained. Ultimately, the consequences of prolonged activity of the allostatic system are detrimental to immune function and the reproductive success of the animal, which in turn raises questions regarding its welfare (Brown and Vosloo, 2017).

Stress affects the mechanisms of innate and adaptive immunity, and although these systems are not mutually exclusive, there is a complex interaction of communication between the two. Innate immunity refers to the mechanism that is evoked immediately or within four hours after the perception of an antigen. Innate immunity includes the body's physical barriers such as the skin and mucous membranes as well as complement and antigen non-specific cellular components. Innate immunity is non-specific and the body's first-line defense to a perceived pathogen. When functioning optimally, pathogens that are encountered daily are prevented from causing disease as their invasion is blocked by the body's physical barriers. Effector cells of the innate immune system such as macrophages, dendritic cells and B cells, also known as professional antigen presenting cells, possess pattern recognition receptors that subsequently recognize the pathogen-associated molecular pattern, and trigger the effector cells to perform their required function. The pattern recognition receptors aid in detecting and eliminating the pathogens from the body and the innate immune response. Innate immunity also allows time for the acquired immune system to develop an antibody response to the detected pathogen, which may take several days or weeks. The cellular components of innate immunity are phagocytic cells such as neutrophils, monocytes and macrophages, which release anti-inflammatory mediators. Natural killer cells are also components of innate immunity and serve as the link between innate and acquired immunity.

Acquired immunity serves to adapt and build a specific immune response for each antigen that is encountered in the body. This type of immunity is characterized by its production of antibodies that are directed against specific antigens and also acquire the ability of immunologic memory that results in a faster and stronger immune response on subsequent detection of the same pathogen. Dendritic and macrophage cells are specialized cells called antigen presenting cells (APCs) and present the detected antigen to a naïve lymphocyte which is a specialized white blood cell that evokes a humoral and cellular immune response (Brown and Vosloo, 2017). The adaptive immune system is comprised of humoral and cellular immunity (Figure 3). Humoral immunity is a part of the adaptive immune system that is evoked by the innate immune system and is known as the antibody-mediated immune response that is responsible for triggering specific B cells to develop into plasma cells. A large number of antibodies are then secreted by these plasma cells and circulated in the blood and the lymph.

Antibodies are a group of proteins called immunoglobulins whose functions differ. Immunoglobulin G (IgG), Immunoglobulin M (IgM) and Immunoglobulin A (IgA) provide defense against viruses, bacteria and toxins, Immunoglobulin E (IgE) offers protection against parasites and allergens, and Immunoglobulin D (IgD) has no evident role in defense. The antibodies of the humoral immune response act by attacking and invading the perceived pathogen, binding to it and subsequently marking the pathogen for destruction by cells called phagocytes. Antibodies can be further categorized by those that activate complement serum proteins or those that bind to antigens. Complement serum proteins that are activated by specific antibodies are then able to destroy the pathogen. Antibodies that bind to the antigens are known as neutralizing antibodies, and once bound the antigen is no longer able to recognize the host cell, therefore inhibiting the further infection of cells (Brown and Vosloo, 2017).

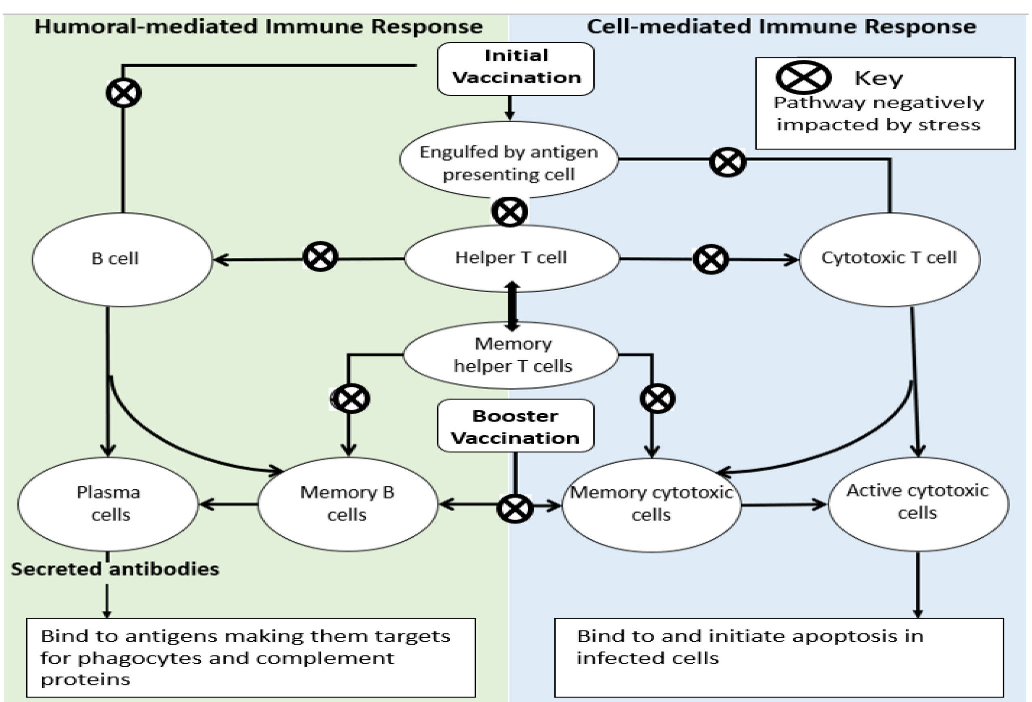

Figure 3. Adaptive immune response: humoral and cell-mediated. Adapted from Campbell and Reece, 2008.

Cellular immunity is also known as cell-mediated immunity (CMI) and is mediated primarily by small lymphocytes derived by the thymus T cells. Two types of T cells exist, the T helper cells and the T killer cells. T helper cells play a crucial role in maximizing the capabilities of the immune system by activating and directing other immune cells to destroy infected cells or pathogens. A second function of the T helper cells is to stimulate B cells to secrete antibodies that activate phagocytes which subsequently activate the killer T cells (Chen et al., 2015).

The major function of killer T cells is its ability to recognize the cytotoxicity of cells infected with a virus and destroy these cells, as well as defending the organism against intracellular bacteria. Intracellular bacteria are not detected by the antibodies and macrophages, and therefore the clearance of infection depends on cytotoxic lymphocytes to eliminate the infected cells. The fact that killer T cells are highly specific with respect to the antigens that they recognize contributes to the uniqueness and effectiveness of the acquired immune response. Glucocorticoids directly influence the activity of the immune system. As previously mentioned, a stressor can be categorized as being acute or chronic. The degree of the perceived stress on the immune system and function may, therefore be bi-directional. Acute stressors may evoke an immuno-enhancing effect, resulting in the proliferation and differentiation of immune cells, whereas chronic stressors have an opposite effect by evoking an immunosuppressive response. The suppression of the immune system is firstly noticed at a cellular level, and as the stress persists, its effects can be examined across the entire immune system. The predominant stressors that result in immunosuppression are transport and handling. These stressors are seen to involve a complex mixture of unfavorable stimuli that act on the animal and depending on the nature of methods used result in lesser or greater effects in stress response. The transport procedure involves handling while loading and unloading, the removal from a familiar to an unfamiliar environment, and disruption of social structure due to mixing with unfamiliar animals. Studies conducted to measure cortisol concentrations during the transport procedures have shown an increase in blood cortisol concentrations, resulting in an increased neutrophil to lymphocyte ratio and ultimately causing increased disease susceptibility to BRD (Chen et al., 2015). The suppression of the immune system may also result in a multifaceted disease complex that arises from viral–bacterial synergy. When the immune system is impaired due to a chronic stress the onset of a primary viral infection may increase the animal's susceptibility to a bacterial infection. An example of this phenomenon is bovine respiratory disease. Cattle whose immune system is already compromised by a viral infection and stress become more susceptible to bacterial pathogens that subsequently invade the bovine respiratory tract resulting in full-blown BRD (Brown and Vosloo, 2017).

Bovine Respiratory Disease

Bovine respiratory disease, also known as shipping fever, is a top health concern of the beef industry. Bovine respiratory disease is one of the most commonly diagnosed causes of morbidity and mortality in cattle, both within large feedlots and smaller traditional pasture-based husbandry systems (Edwards, 2010; Murray et al., 2016). Morbidity attributed to BRD accounts for approximately 75 percent of total feedlot morbidity (Wilson et al., 2017). A 2007 study that examined calf mortality levels and causes of mortality as reported by producers found respiratory problems like BRD accounted for 31 percent of calf deaths over three weeks of age (USDA-APHIS, 2010). Pathogenesis of infectious respiratory disease in cattle is driven by complex interactions. Factors of disease are associated with the animal, pathogen, and environment which creates significant challenges in its control (Edwards, 2010). Due to the multifactorial causes

BRD is referred to as a complex disease (Figure 4). Causes can be viral (Bovine Respiratory Syncytial Virus Parainfluenza 3, Adenovirus, Bovine Viral Diarrhea Virus, and Infectious Bovine Rhinotracheitis); bacterial (*Pasteurella multocida, Mannheimia haemolytica, Histophilus somni, Mycoplasma bovis*); parasitic (lungworm); and/or fungal (Aspergillus). The traditional model of BRD states a primary viral infection followed by secondary bacterial opportunism as the cause. Recent research challenges the traditional as being overly simplistic as it fails to acknowledge the role of some pathogens that were previously considered of minor importance, or not detected (Murray et al., 2016).

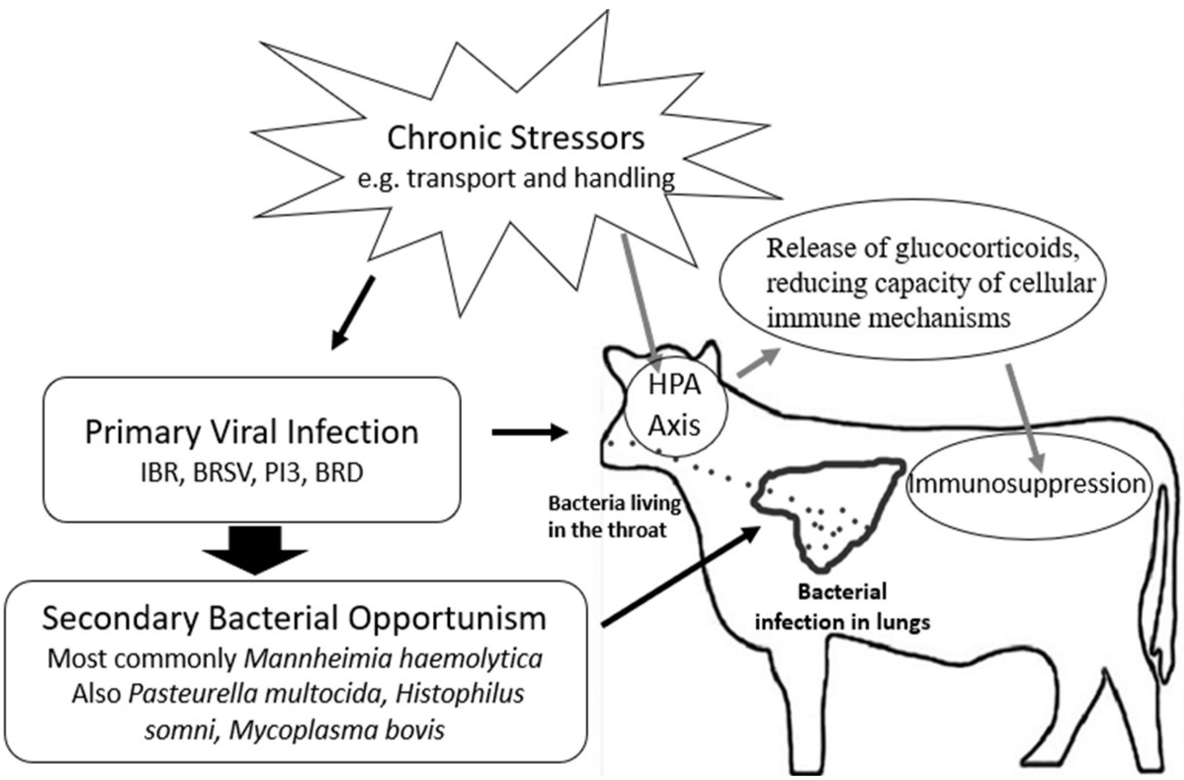

Figure 4. Complex interactions of BRD. Adapted from Zoetis, 2014.

Cattle with BRD display a range of visual symptoms such as labored breathing, coughing, decreased appetite, depression, droopy ears, eye discharge, fever, or nasal discharge (Schneider et al., 2009). The first line of defense of the innate immune system is the respiratory epithelial surface which provides mechanical, chemical, and microbiological barriers to prevent infection of BRD associated pathogens. Nasal passages of healthy and stressed calves contain opportunistic bacteria including pathogens such as *Mannheimia haemolytica* as shown in Figure 5. Stressed calves are found to have a higher density of these bacteria in the nasal passages.

A study found that within four hours healthy animals are able to clear 90 percent of an inhaled administered dose of bacteria. Coinfection with a virus or bacterium, like *Mycoplasma bovis*, impairs clearance of the infecting bacteria which results in lesions in the respiratory track (Griffin, 1997; Griffin et al., 2010). Pathogens of BRD can vary in clinical symptoms. Bovine respiratory syncytial virus (BRSV) infection is age and immune status dependent, with most cattle being asymptomatic. Primary infection of the nasal cavity, pharynx, trachea, bronchi, and bronchiole epithelial cells induces loss of cilia or necrosis of bronchial and bronchiolar epithelial cells. The reduced clearance leads to a buildup of fluid and cellular debris in the airways and alveoli providing an ideal environment for bacterial colonization. Bovine herpes virus-1 (BHV-1) initially infects the epithelial cells of the upper respiratory tract, and then spreads to the lower respiratory tract. Necrosis of epithelial cells causing ineffective mucociliary clearance, and lesions in the mucosa of the upper respiratory tract exacerbates secondary bacterial infections. Parainfluenza type 3 (PI-3) virus infections are associated with little or no clinical symptoms in cattle, but PI-3 does predispose lung tissue for secondary bacterial infections. Primary infections occur in the epithelial cells in the trachea, bronchi and alveoli, causing necrosis of the ciliated epithelium. This condition results in ineffective mucociliary clearance of fluid, dust, and cellular debris from the airways. Development of clinical disease is associated with stress and exposure to secondary infections by other viral or bacterial pathogens. These factors, individually or in combination, can provide increased opportunity for persistent bacterial infection due to an impaired innate immune response (Griffin et al., 2010).

Other potential bacterial organisms are isolated from bovine pneumonic lung tissues, such as *Arcanobacterium pyogenes*, multiple species of the Pasteurella and *Mycoplasma genera*, gram-positive staphylococci and streptococci, and multiple enteric organisms. Currently available *Pasteurella multocidia* vaccines for use in cattle are often optional in preconditioning programs as the field efficacy of the vaccines is not well documented and requires more research (Dabo et al., 2007). Occasionally fungal organisms are recovered. Organisms can be opportunistic pathogens or associated with chronic cases of pneumonia after prolonged antimicrobial therapy. Fungi colonize necrotic tissue in cases where animals survive the initial infectious processes. Fungal organisms are also generally considered to be part of the normal upper respiratory tract microbiome. Isolation is potentially coincidental, and further research is needed to indicate a causal relationship (Griffin et al., 2010).

Clinical signs are typically observed in calves seven to ten days after a stressful event, or as late as twenty-seven days after arrival. Organisms shed from the nasal cavity are a source of infection that is spread through inhalation of droplets containing the bacteria, by direct contact, or by ingesting feed or water supplies contaminated with nasal discharge of infected animals. Identification of sick animals is a major concern of BRD. Traditionally, feedlot personnel evaluate cattle health subjectively based on cattle behavior and appearance which have limited sensitivity of 62 percent for detecting BRD. As prey animals, cattle natural behavior in response to human presence is to mask early symptoms of disease, delaying or preventing detection and treatment. Early intervention is vital to effective BRD treatment resulting in lower relapse rates and lower mortality (Griffin, 2010).

Cattle with BRD are often detected late in the disease process, or not detected at all. Most respiratory disease cases reported from cattle producers are based on a simple set of observations, applied to cattle considered to be at a high risk for developing BRD. Most commonly targeted are stressed or newly received cattle. Observations target common signs that include depression, appetite loss, respiratory character change, and temperate elevation (DART). Clinical signs are not pathognomonic for bacterial pneumonia. DART is useful with examining case treatment records to determine incidence rates, management, environmental, and nutritional causal relationships. However, BRD mortality in groups of cattle is poorly related to the BRD case treatment records. Consequently, 63 percent of clinically diagnosed, treated cattle are not affected by BRD. Accurate prognosis of BRD at the time of treatment is crucial for effective management. An increase in specificity of BRD diagnosis would lead to more prudent use of antimicrobials and lower costs of BRD control in feedlots (Griffin, 1997; Griffin et al., 2010).

Even with substantial advances in antibiotics against respiratory pathogens, 21 percent of cattle arriving with a bodyweight of less than 318 kg, and nine percent of cattle weighing at least 318 kg are affected by BRD during the feeding phase (Wolfger et al., 2015). Bovine respiratory disease presents the most economic ramifications from a health stance, in the cattle industry. The United States feedlot industry estimates an annual loss as high as one billion dollars due to loss of production, increased labor expenses, drug costs, and death because of BRD (Rice, 2008). Detrimental economic effects of BRD increase with disease severity, and the number of treatments administered. Producers lose an estimated $40.46 per calf for one treatment, $58.35 per calf for two treatments, and $291.93 per calf for three or more treatments for BRD. This cost is increased when indirect costs are also considered, such as the reduction of average daily gain and loss of carcass value due to a less desirable quality grade. Average day of first treatment for

BRD is forty days after entering the feedlot, with 75 percent of treated cattle treated by day fifty-five. First few weeks upon entering the feedlot is the most critical time period to observe cattle for BRD (Schneider et al., 2009). Cost related to treating BRD make vaccinations a selling point for producers.

Blackleg

Another health concern of the beef industry is blackleg. Also known as black quarter, blackleg is caused by the organism *Clostridium chauvoei*. Difficult to kill, *Clostridium chauvoei* can persist as a spore in the soil for many years, especially in swampy land. Blackleg bacilli enter puncture wounds that cattle can receive from barbed wire, plant thorns, or other sharp objects commonly found on operations. Symptoms include elevated body temperature, gaseous swelling around hips or shoulders, decreased feed intake, rapid respiration, and depression. Accumulated toxin causes stiffness, lameness, and potential paralysis. Within two to five days after exposure, body temperature will decrease rapidly, and convulsions develop. Muscle tissue will appear blackened with streaks of dark red. Calves ranging from six to eighteen months of age are the most susceptible to Blackleg (Rings, 2004).

Parasites

Also included in value-added programs is the control of internal parasites. In general, younger animals and animals that are experiencing a higher level of stress are most likely to show signs of parasitism. Subclinical effects of parasitism cause a loss in animal productivity, such as average daily gain and altered carcass composition. Cattle infected with parasites will also have clinical symptoms including anemia, edema, and diarrhea. The subclinical effects are of major economic importance to the producer. Cattle can be infected by roundworms (nematodes), tapeworms (cestodes), and flukes (trematodes). Roundworms are considered the most economically devastating internal parasites of livestock. The medium or brown stomach worm and Cooperia species are the most common roundworms. Although cattle can be infected with tapeworms, their effect on animal performance is minimal compared to the roundworms. Transmission of internal parasites, also known as helminths, occurs through oral ingestion when cattle are grazing or by direct skin penetration by larval parasites on pasture (Clark et al., 2015).

METHODS

Data Collection

Data for this study was collected between March 2009 and December 2018 at Joplin Regional Stockyards (JRS), a sale barn near Carthage, Missouri. Although cattle were sold through the same livestock auction, different marketing strategies were used. Cattle were sold through value-added, video, or traditional auctions. The use of provided market data negated Institutional Animal Care and Use Committee approval. Market data from value-added, video, and traditional feeder sales over the study period included 521,586 lots encompassing 3,400,621 head of cattle (Table 1). Joplin Regional Stockyards is the largest sale barn in Missouri and ranks within the top ten nationwide for cattle sales. Descriptive factors in the data from JRS that could affect the sale price of cattle included date of the auction, weight per head of cattle, number of cattle in each lot, gender, auction type, and color/ breed influence.

Table 1. Number of cattle sold through Joplin Regional Stockyards by auction type and gender, 2009-2018.

	Gender		
Auction	Steer	Heifer	Bull
Traditional	1,565,206	1,020,296	33,621
Value-added	172,668	90,873	0
Video	363,943	151,796	3,218

Data for each year of the study was used to evaluate the effect of preconditioning on the bid price per hundredweight (cwt) of beef cattle in value-added and video sales in comparison to traditional feeder sales on the bid price per cwt of beef cattle. Cattle were from lots that had a recorded sale price and consisted of bulls, steers, or heifers that ranged in weight from 350 to 1,000 pounds (Table 2).

Table 2. Number of cattle sold through Joplin Regional Stockyards by weight class and gender, 2009-2018.

	Gender		
Weight Class	Steer	Heifer	Bull
350-399	55,892	55,861	4,558
400-499	248,213	235,723	11,719
500-599	422,939	349,179	9,498
600-699	420,282	294,628	4,804
700-799	382,969	243,149	2,161
800-899	419,748	70,264	1,792
900-1,000	151,774	14,161	2,307

Weight categories were sorted to reflect reports by the National Daily Feeder and Stocker Cattle Summary (USDA-AMS, 2019). Data for cattle that were outside the above weight parameters, or had no sale occur were not included in the study. Effect of breed or color composition was evaluated within a single gender. Colors/ breed influence in cattle were noted by JRS as black, white, Charolais, black with white face, red, mixed, unknown, Simmental Cross, and Brahman (Table 3). Dates were isolated and factored by year and month of sale to account for trends in the market price. Lot sizes were broken up to reflect natural breaks observed in the market from what is offered by producers for sale with buyers' desire for a trailer load of uniform cattle (Table 4). Lot sizes ranged from including one animal to over 75 cattle in a lot.

Value-added Sale Requirements

All value-added programs at JRS require castration of origin bulls, heifers guaranteed

Table 3. Number of cattle sold through Joplin Regional Stockyards of all auction types by breed/ color influences and gender, 2009-2018.

	Gender		
Breed/Color	Steer	Heifer	Bull
Black	645,113	430,952	1,722
Brahman	487	142	49
Black white face	16,854	12,002	95
Charolais	105,859	85,934	316
Mixed	1,103,060	631,722	33,717
Red	76,908	50,776	624
Simmental cross	624	469	11
Unknown	27,856	580	221
White	3,774	3,052	102

Table 4. Number of cattle sold through Joplin Regional Stockyards of all auction types by lot sizes and gender, 2009-2018.

	Gender		
Lot Size	Steer	Heifer	Bull
1	112,392	4,373	35,492
2-6	345,621	13,370	931
7-10	231,578	8,684	161
11-25	420,511	17,367	166
26-50	233,461	8,473	34
51-75	200,343	22,316	55
75+	557,911	77,213	0

open and all cattle dehorned. Producers marketing cattle in value-added sales must have turned in proof of purchase or farm origin, and completed Value-Added Form one week prior to sale date (Table 5). Commission for JRS is $18 per head of cattle with an additional $0.12 per head of

Table 5. Management requirements of value-added sales designated by Joplin Regional Stockyards.

Beef Program	Required Management	Documentation
All Value-Added	Bulls Castrated Implants in steers optional Heifers guaranteed "Open" Polled or dehorned	Completed Value-Added form one week prior to sale Cattle have approved visual tag
Calf-Vac Sourced	Calves received one round of vaccinations 6 weeks prior to sale date	Calves born on producer's farm
Wean-Vac 45 Sourced	Cattle given 2 rounds of vaccinations MLV[1] booster given 2-5 weeks after the first vaccination Weaned at least 45 days	Calves born on producer's farm
Wean-Vac 45 Non-sourced	Cattle given 2 rounds of vaccinations MLV[1] booster given 2-5 weeks after first vaccination Weaned at least 45 days	Producers have proof of purchase of cattle

[1]MLV= Modified Live Vaccination.

veterinarian inspection, $1.50 per head for value-added tag, and $0.50 per head for data charge.

cattle for veterinarian inspection, $1.50 per head for value-added tag, and $0.50 per head for data charge. Each lot of calves, verified by personnel of the livestock auction service as qualifying for a certified health program, are identified in sale catalogues by date. For data analysis in this study, the separate value-added health programs were grouped together as one descriptive factor. The livestock auction has designated programs, including Calf-Vac Sourced, Wean-Vac 45 Sourced, and Wean-Vac 45 Non-Sourced. Vaccination and management requirements for each certified health program were designated by JRS (Tables 5, 6).

Table 6. Vaccine protocol in value-added programs designated by Joplin Regional Stockyards.

Beef Program	Vaccine	1st Vaccination Required	2nd Vaccination "Booster" Required
Calf-Vac Sourced	Respiratory (IBR-BVD-P13-BRSV)	Yes	No
	Clostridial/ Blackleg	Yes	No
	Haemophilus Somnus	Optional	No
	Mannheimia Haemolytica		
Wean-Vac 45 Sourced	Respiratory (IBR-BVD-P13-BRSV)	Yes	Yes (MLV[1])
	Clostridial/ Blackleg	Yes	Yes
	Haemophilus Somnus	Optional	No
	Mannheimia Haemolytica	Yes	No
Wean-Vac 45 Non-sourced	Respiratory (IBR-BVD-P13-BRSV)	Yes	Yes (MLV[1])
	Clostridial/ Blackleg	Yes	Yes
	Haemophilus Somnus	Optional	No
	Mannheimia Haemolytica	Yes	No

[1]MLV= Modified Live Vaccination.

Video Sale Requirements

Video sales often contain load lots of 50,000 pounds of cattle. Sales containing less than 40,000 pounds of cattle in a load lot often require trucking allowance negotiations. Benefits to the video seller may outweigh the additional trucking allowance cost. While some sellers may not have a load lot, they may still choose to utilize video sales due to convenience and reduced risk of unsatisfactory prices on sale day as there is no cost for "no sale" cattle in video sales. Marketing cattle through video auction also requires a visit from a livestock marketing representative. Representatives view and videotape a fair representation of the cattle with a video camera in their natural surroundings and complete a consignment contract that describes the cattle and the terms and conditions of the sale. Consignment contract is submitted to the sale barn where the information is entered into a computer database and a catalog is prepared. Information about the cattle in the catalog includes date of delivery, base weight of the cattle at delivery, price slide conditions, description of the cattle, health program, and nutrition programs. Video auction catalog can be viewed on the internet prior to the auction and listings can be viewed on the internet at any time. An example of the video catalog is in Figure 5. Video of the cattle for sale is also made available on the internet for buyers to view prior to the auction. On auction day, buyers and sellers can either be present at the auction site or view the auction via the internet. Video and internet auctions are conducted live, with an auctioneer, as cattle are sold to buyers bidding at the auction site, via telephone or on the internet. After the cattle are sold, a livestock contract stating the terms and conditions of the sale is prepared and sent to both the buyer and seller. Commission Rates for video auctions vary; JRS utilizes Primetime Video and offers a flat rate of $20.00 per head of cattle. Following the auction, the representative contacts all parties to arrange the delivery. On the day of delivery, the representative is present to oversee the sorting and loading of the cattle. At delivery, the seller is issued a check drawn on the livestock auction's bonded custodial account and payment is due from the buyer upon receipt of the cattle. The cattle are shipped directly from the seller's farm or ranch to the buyer's destination.

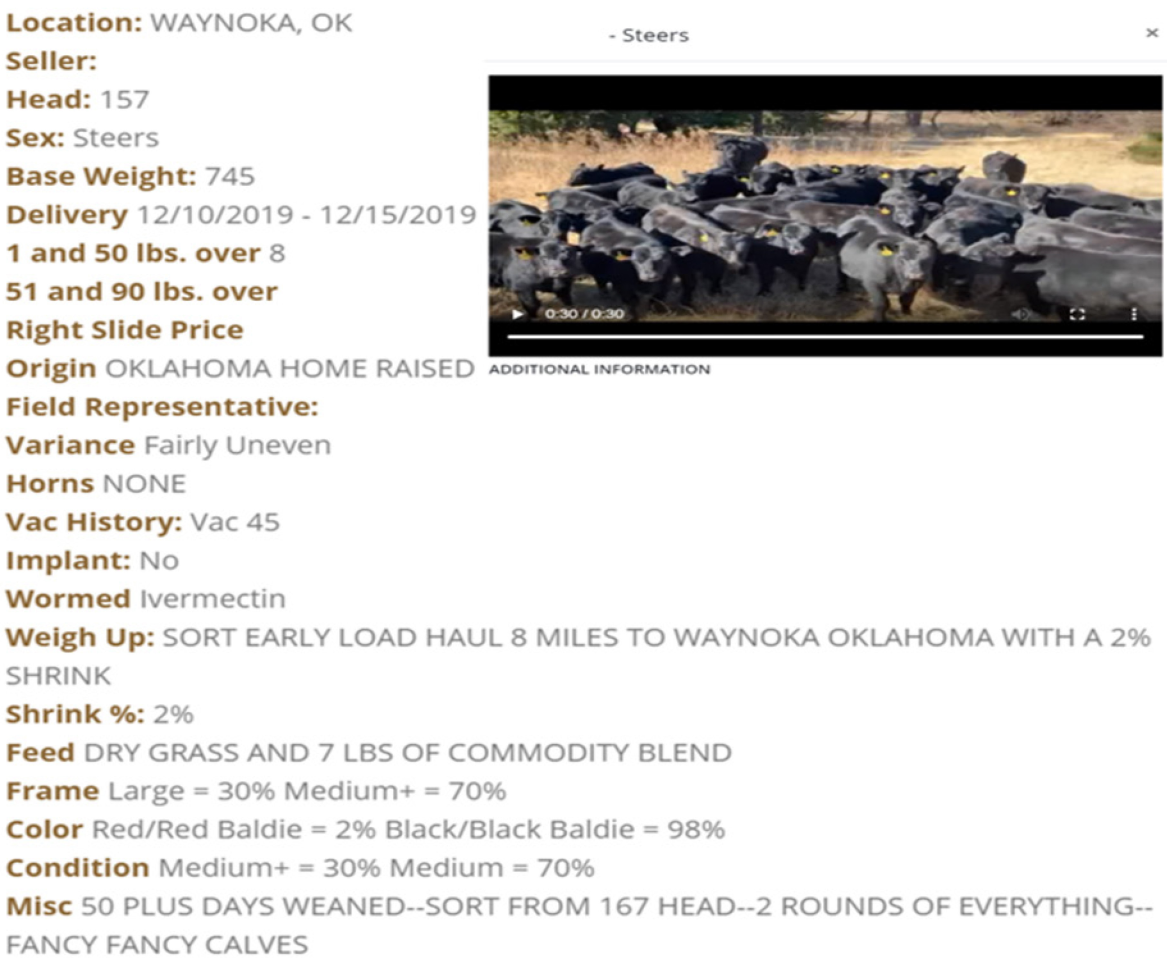

Figure 5. JRS Video Sale Catalog. Image Credit: Prime Time Livestock Video Auctions, 2019.

Statistical Analysis

Increasing vertical coordination throughout the beef industry has created price signals for specific cattle traits. Desired traits by stockers, feedlots, packers, and consumers are signaled through market premiums to cow-calf producers. Objective data was analyzed via one-way

ANOVA with Tukey pairwise comparison to identify trends and significant values. All lot characteristics that could be accurately quantified or categorized were used to develop a regression model that evaluated the effects of independent factors on sale price. Ordinary least squares (OLS) regression, a multiple linear regression method, was used to estimate the relationship between dependent variables and explanatory variables. OLS regression provides the best estimates when all assumptions are met, therefore it is best to test for assumptions. Common approaches to this testing include examining residual plots and viewing the correlation between predictors using the variance.

The proposed model tests the effects of several categorical variables (X) that are hypothesized to explain the dependent variable (Y), bid price in dollars per cwt. A multiple-regression model was developed using a backwards elimination procedure to quantify the effects of objectively measured categorical variables on the sale price of feeder calves. In this backwards elimination procedure, the variable with the largest nonsignificant P-value was eliminated from the model, at α removed = 0.1. A value of $P<0.05$ was required for a fixed effect to remain in the model. The independent variables included in the final model for lots of calves were 1) year and month of sale, 2) gender of lot, 3) color/ breed description, 4) sale type, 5) lot weight category, 6) size of the lot. Variance inflation factor (VIF) below 10 was used to indicate multicollinearity between variables and did not have a large effect on the model, improving the accuracy of the model.

Linear regression analysis with Type III error was used in Minitab 19 (Minitab Inc., State College, PA). Basic model of the regression equation is as follows:

$$Y = a + b_1 \text{ AT} + b_2 \text{ WC} + b_3 \text{ CB} + b_4 \text{ LS} + b_5 \text{ MY} + b_6 \text{ G} + e$$

In this model, Y is bid price (dollars/cwt), AT is auction type, WC is weight class, CB is color/ breed influence, LS is lot size, MY is month and year of sale, G is Gender (Steer, Heifer, Bull), *a* is intercept, *b* is slope of the line, and *e* is error term.

RESULTS

The objective of this study was to analyze feeder cattle characteristics influence on market price in traditional auctions. The secondary objective was to quantify any price premiums for marketing strategies of video or value-added over traditional sales. Objective data was first summarized and analyzed to identify trends in the data via descriptive statistics. Regression analysis was then used to analyze the significance of categorical variables on the bid price.

Descriptive statistics for each auction type were recorded in Tables 7 to 9. Most cattle were sold through traditional sales, with 89 percent of steers and 92 percent of heifers sold at JRS going through traditional sales as shown in Tables 7 and 8. Tukey pairwise comparisons found steer sale types significantly different from each other. In Table 7, steers had a mean bid price of +$1.72 value-added, +$4.15 video sales per cwt compared to traditional sales when looking at all years of the study, 2009-2018.

Table 7. Descriptive statistics of steer bid prices in dollars per cwt sold through Joplin Regional Stockyards by auction type, 2009-2018.

Auction	N	Mean	SD[1]	Variance	CV[2]
Value-added	8,021	$153.91[c]	46.46	2158.61	30.19
Traditional	248,148	$152.19[a]	48.86	2386.98	32.10
Video	22,811	$156.34[b]	44.58	1987.20	28.51

[a-c] Means in a row without same superscript letter differ ($P < 0.05$) as analyzed by One-way ANOVA.
[1]SD = Standard Deviation.
[2]CV = Coefficient of Variation.

Heifers in traditional sales with a mean bid price of $139.70 per cwt and value-added sales $140.75 per cwt did not differ. Video sales $144.55 per cwt were different than traditional and value-added sales (Table 8). Steers in traditional sales had a higher mean bid price of +$0.41 per cwt overall when compared to bulls in traditional sales at $151.78 per cwt (Table 9).

Table 8. Descriptive statistics of heifer bid prices in dollars per cwt sold through Joplin Regional Stockyards by auction type, 2009-2018.

Auction	N	Mean	SD[1]	Variance	CV[2]
Value-added	6,128	$140.75^b	42.08	1770.66	29.90
Traditional	189,393	$139.70^b	42.39	1796.64	30.34
Video	11,234	$144.55^a	41.39	1712.76	28.63

[ab] Means in a row without same superscript letter differ ($P < 0.05$) as analyzed by One-way ANOVA.
[1]SD = Standard Deviation.
[2]CV = Coefficient of Variation.

Table 9. Descriptive statistics of bull and steer bid prices in dollars per cwt sold through Joplin Regional Stockyards' traditional auctions, 2009-2018.

Gender	N	Mean	SD[1]	Variance	CV[2]
Bull	32,628	$151.78^a	49.61	2461.37	32.69
Steer	248,148	$152.19^b	48.86	2386.98	32.10

[ab] Means in a row without same superscript letter differ ($P < 0.05$) as analyzed by One-way ANOVA.
[1]SD = Standard Deviation.
[2]CV = Coefficient of Variation.

When data was broken down further by gender and weight classes of 500-899 pounds, 61 percent of steers and 91 percent of heifers were sold through traditional sales (Tables 10, 11). Steers 500-899 pounds from value-added sales sold for mean bid price of +$5.12 per cwt and video sales for mean bid of +$1.48 per cwt more than for steers in traditional sales (Table 10). Heifers 500-899 pounds sold for mean bid price of +$3.83 per cwt for value-added sales and +$2.74 per cwt for video sales compared to traditional sales (Table 11).

Table 10. Descriptive statistics of steers 500-899 pounds bid prices in dollars per cwt sold through Joplin Regional Stockyards by auction type, 2009-2018.

Auction	N	Mean	SD[1]	Variance	CV[2]
Value-added	6,356	$151.14[a]	43.09	1856.70	28.51
Traditional	163,755	$146.02[b]	43.84	1922.12	30.02
Video	98,800	$147.50[c]	37.89	1435.92	25.69

[a-c] Means in a row without same superscript letter differ (P < 0.05) as analyzed by One-way ANOVA.
[1]SD = Standard Deviation.
[2]CV = Coefficient of Variation.

Table 11. Descriptive statistics of heifers 500-899 pounds bid prices in dollars per cwt sold through Joplin Regional Stockyards by auction type, 2009-2018.

Auction	N	Mean	SD[1]	Variance	CV[2]
Value-added	4,570	$137.91[a]	39.61	1568.98	28.72
Traditional	112,075	$134.08[b]	38.32	1468.58	28.58
Video	6,855	$136.82[a]	36.20	1310.46	26.46

[ab] Means in a row without same superscript letter differ (P < 0.05) as analyzed by One-way ANOVA.
[1]SD = Standard Deviation.
[2]CV = Coefficient of Variation.

Descriptive statistics for each lot size were recorded in Tables 12 to 14. When evaluating all years of the study across all sale types, Tukey pairwise comparison found lots containing 7-

10, 11-25, and 50-75 cattle were significantly different from all other size lots. Lot sizes of 1 and over 75 cattle were not different from each other, as well as lots containing 2-6 and 26-50 cattle (Table 12). The highest mean bid price for steers $158.26 per cwt (Table 12) and heifers $143.31 per cwt (Table 13) was found in lots containing 7-10 cattle.

Table 12. Descriptive statistics of steer bid prices in dollars per cwt sold through Joplin Regional Stockyards by lot size, 2009-2018.

Lot Size	N	Mean	SD[1]	Variance	CV[2]
1	112,392	\$149.71[d]	50.81	2581.33	33.94
2-6	98,800	\$153.74[c]	48.56	2357.76	31.58
7-10	28,059	\$158.26[a]	46.11	2126.11	29.14
11-25	26,784	\$156.16[b]	43.27	1872.26	27.71
26-50	6,812	\$153.13[c]	40.30	1624.09	26.32
50-75	3,301	\$141.68[e]	36.74	1349.57	25.93
75+	2,832	\$147.14[d]	38.42	1475.89	26.11

[a-e] Means in a row without same superscript letter differ ($P < 0.05$) as analyzed by One-way ANOVA.
[1]SD = Standard Deviation.
[2]CV = Coefficient of Variation.

Tukey pairwise comparison of Table 13 found less differences among cattle lot sizes of 2-6, 26-50, and over 75 not different. In bulls, Tukey pairwise comparisons found a difference of lots of one, mean sale price of $153.32 per cwt, when compared to the other lot sizes (Table 14). It should be noted that there were too few lot sizes of over 25 bulls for findings to be significant. For bulls across all sale types the lowest mean price $92.30 per cwt was found in lots containing 2-6 calves (Table 14).

Table 13. Descriptive statistics of heifer bid prices in dollars per cwt sold through Joplin Regional Stockyards by lot size, 2009-2018.

Lot Size	N	Mean	SD[1]	Variance	CV[2]
1	83,435	\$137.21[c]	43.85	1922.58	31.96
2-6	75,758	\$141.31[b]	42.31	1790.53	29.94
7-10	21,547	\$143.84[a]	40.48	1638.64	28.14
11-25	19,298	\$142.91[a]	38.70	1487.96	27.08
26-50	3,863	\$140.24[b]	37.24	1386.73	26.55
50-75	1,629	\$135.32[c]	35.26	1243.28	26.06
75+	1,225	\$139.18[bc]	36.93	1363.98	26.54

[a-c] Means in a row without same superscript letter differ ($P < 0.05$) as analyzed by One-way ANOVA.
[1]SD = Standard Deviation.
[2]CV = Coefficient of Variation.

Table 14. Descriptive statistics of bull bid prices in dollars per cwt sold through Joplin Regional Stockyards by lot sizes containing 1-25 cattle, 2009-2018.

Lot Size	N	Mean	SD[1]	Variance	CV[2]
1	35,519	\$153.49[a]	49.23	2423.99	32.08
2-6	325	\$92.30[b]	25.07	628.39	27.16
7-10	21	\$95.07[b]	23.28	542.16	24.49
11-25	11	\$106.00[b]	40.50	1640.20	38.19

[ab] Means in a row without same superscript letter differ ($P < 0.05$) as analyzed by One-way ANOVA.
[1]SD = Standard Deviation.
[2]CV = Coefficient of Variation.

Mean bid price in steers, heifers, and bulls increase as weight class in pounds decreases (Table 15 to 17). Significant differences were found between all weight classes of steers when using Tukey pairwise comparison. Highest bid price means were found for weight class 350-399 pounds for steers $172.52 per cwt (Table 15), heifers $154.33 per cwt (Table 16), and bulls $181.90 per cwt (Table 17). Lowest mean bid prices in all sale types were found for weight class 900-1,000 pounds across all genders. In steers, the highest volume was marketed in the 700-799-pound weight class with 131,307 cattle for all sale types (Table 15).

Table 15. Descriptive statistics of steer bid prices in dollars per cwt sold through Joplin Regional Stockyards by weight classes 350-1,000 pounds, 2009-2018.

Weight Class, pounds	N	Mean	SD[1]	Variance	CV[2]
350-399	20,652	$172.52[a]	60.35	3642.51	34.98
500-599	80,351	$154.98[b]	46.58	2169.86	30.06
600-699	58,208	$143.69[c]	41.17	1694.78	28.65
700-799	131,307	$136.28[d]	37.26	1388.55	27.34
800-899	14,867	$130.89[e]	34.62	1220.67	26.69
900-1,00	5,607	$122.84[f]	33.62	1130.07	27.37

[a-f] Means in a row without same superscript letter differ ($P < 0.05$) as analyzed by One-way ANOVA.
[1]SD = Standard Deviation.
[2]CV = Coefficient of Variation.

Across all sale types of heifers, 500-599-pound weight class contained the most cattle sold (Table 16). Significant differences were found between all weight classes of heifers when using Tukey pairwise comparison. In bulls, weight class 400-499 pound was the largest for all the sale types 2009-2018 (Table 17). Tukey pairwise comparison found significant differences between all weight classes of bulls. Descriptive statistics for each color/ breed were recorded in Tables 18 to 20. In steers through all auction types, Tukey pairwise comparison determined no difference between Charolais, black with white face, and mixed cattle (Table 18).

Table 16. Descriptive statistics of heifer bid prices in dollars per cwt sold through Joplin Regional Stockyards by weight classes 350-1,000 pounds, 2009-2018.

Weight Class, pounds	N	Mean	SD[1]	Variance	CV[2]
350-399	20,023	$154.33[a]	50.37	2537.36	32.64
400-499	60,021	$148.40[b]	44.87	2013.14	30.23
500-599	61,258	$140.01[c]	40.31	1625.21	28.79
600-699	36,925	$132.68[d]	36.17	1308.45	27.26
700-799	17,856	$125.32[e]	33.41	1116.29	26.66
800-899	7,461	$118.14[f]	31.84	1013.90	26.95
900-1,000	3,211	$109.54[g]	30.00	900.13	27.39

[a-f] Means in a row without same superscript letter differ (P < 0.05) as analyzed by One-way ANOVA.
[1]SD = Standard Deviation.
[2]CV = Coefficient of Variation.

Table 17. Descriptive statistics of bull bid prices in dollars per cwt sold through Joplin Regional Stockyards by weight classes 350-1,000 pounds, 2009-2018.

Weight Class, pounds	N	Mean	SD[1]	Variance	CV[2]
350-399	4,555	$181.90[a]	53.47	2859.36	29.40
400-499	11,719	$168.24[b]	47.48	2254.60	28.22
500-599	9,495	$154.03[c]	40.92	1674.53	26.57
600-699	4,738	$140.01[d]	36.16	1307.88	25.83
700-799	2,044	$119.26[e]	33.85	1145.71	28.83
800-899	1,458	$99.44[f]	30.51	930.89	30.68
900-1,000	1,869	$91.16[g]	27.50	756.54	30.17

[a-g] Means in a row without same superscript letter differ (P < 0.05) as analyzed by One-way ANOVA.
[1]SD = Standard Deviation.
[2]CV = Coefficient of Variation.

Also, no difference was found when comparing steers white in color to Simmental cross breeds. Brahman breed at $86.31 per cwt had the lowest mean bid price across all auctions of steers.

Table 18. Descriptive statistics of steer bid prices in dollars per cwt sold through Joplin Regional Stockyards by color, 2009-2018.

Color/Breed	N	Mean	SD[1]	Variance	CV[2]
Unknown	27,857	162.65^{a}	46.19	2133.38	28.40
Black	103,216	154.60^{b}	48.78	2379.41	31.55
Mix	95,091	150.84^{c}	47.96	2300.28	31.80
Black white face	5,957	150.36^{c}	51.71	2673.46	34.39
Charolais	22,170	150.06^{c}	49.23	2423.76	32.81
Red	20,414	143.72^{d}	47.34	2240.73	32.94
White	3,773	137.35^{e}	46.87	2196.34	34.12
Simmental Cross	370	130.29^{e}	44.37	1968.47	34.05
Brahman	132	86.31^{f}	42.24	1784.23	48.94

[a-f] Means in a row without same superscript letter differ ($P < 0.05$) as analyzed by One-way ANOVA.
[1]SD = Standard Deviation.
[2]CV = Coefficient of Variation.

Heifers of Brahman breed had the lowest mean bid price of $77.18 per cwt and were the smallest population across all auctions (Table 19). In heifers, white, red, Simmental Cross and Brahman cattle were all found to be different by Turkey Pairwise Comparison. Cattle that were labeled as mix, black, or unknown were not found to be different nor were cattle that were black with white faces or Charolais breed different when compared across heifers.

In bulls from all auction types, Brahman cattle again had the lowest mean of $86.31 per cwt and the least amount sold (Table 20). Few differences were found using Tukey pairwise comparison between the different colors and breeds of bulls. Red and unknown color/breed were not different from each other. However, red and unknown were different when compared to all other breeds/colors in bulls (Table 20).

Table 19. Descriptive statistics of heifer bid prices in dollars per cwt sold through Joplin Regional Stockyards by color, 2009-2018.

Color/Breed	N	Mean	SD[1]	Variance	CV[2]
Unknown	579	\$143.92[a]	17.39	302.44	12.08
Mix	88,589	\$141.65[a]	41.50	1722.38	29.30
Black	76,631	\$141.30[a]	42.98	1847.12	30.42
Charolais	17,571	\$136.69[b]	42.59	1813.72	31.16
Black white face	4,487	\$136.29[b]	44.89	2015.56	32.94
Red	15,482	\$131.80[c]	41.70	1738.90	31.64
White	3,051	\$127.79[d]	41.96	1760.78	32.84
Simmental cross	298	\$117.84[e]	39.88	1590.32	33.84
Brahman	67	\$77.18[f]	38.23	1461.51	49.53

[a-f] Means in a row without same superscript letter differ ($P < 0.05$) as analyzed by One-way ANOVA.
[1]SD = Standard Deviation.
[2]CV = Coefficient of Variation.

The regression model included all 521,586 lots of cattle observations. Tables 21 and 22 include the results of this model. With a R-squared of 81.87, the model explains most of the variability of the response data around the mean and has a high predictability for this data set. Low VIF scores indicated little effect of multicollinearity on the model (Table 21). Regression model correlation coefficients support a positive effect seen for video and value-added bid price over traditional auction sales.

Table 20. Descriptive statistics of bull bid price in dollars per cwt sold through Joplin Regional Stockyards by color, 2009-2018.

Color/Breed	N	Mean	SD[1]	Variance	CV[2]
Mix	33,379	$156.97[a]	48.08	2311.96	30.63
Red	226	$153.80[a]	14.07	198.00	9.15
Black white face	93	$96.54[b]	30.39	923.41	31.48
Simmental cross	8	$96.30[b]	41.10	1689.60	42.68
Black	1,251	$93.35[b]	27.53	758.01	29.49
Charolais	251	$93.14[b]	26.79	717.76	28.76
Unknown	522	$92.33[b]	25.68	659.45	27.81
White	101	$90.97[b]	20.12	404.91	22.12
Brahman	47	$74.99[b]	19.69	387.68	26.26

[ab] Means in a row without same superscript letter differ ($P < 0.05$) as analyzed by One-way ANOVA.
[1]SD = Standard Deviation.
[2]CV = Coefficient of Variation.

All auction types were found to have a significant ($P < 0.05$) effect on sale bid price, with overall mean bid price of value-added sales $148.13 per cwt, video sales $153.49 per cwt, and traditional sales $147.13 per cwt. Year and month categories saw fluctuating trends reflecting market trends in years and quarters. Gender had a significant ($P < 0.05$) effect on bid prices (Table 21). All lot sizes were found to have a significant ($P < 0.05$) effect on sale bid price, with positive correlation coefficients on lots containing less than 75 cattle (Table 21).

Weight classes 350-1,000 pounds were significant ($P < 0.05$), with positive correlation coefficients on lighter weight classes (Table 22). Most colors/breed influences were found to have a significant ($P < 0.05$) effect on sale bid price as shown in Table 23. Charolais were not significant (P = 0.051) as compared to mixed lots. Color/ breed influence had a significant (P < 0.05) effect on the bid price, except for Charolais breed influence (P > 0.05) (Table 22).

Table 21. Regression analysis of cattle bid prices in dollars per cwt versus auction type, gender, and lot size sold through 2009-2018 at Joplin Regional Stockyards.

Term	Coef[1]	SE Coef[2]	T-Value	P-Value*	VIF[3]
Constant[4]	101.11	0.26	386.83	P < 0.002	---
Auction Type					
Value-Added	3.47	0.17	19.57	P < 0.002	1.10
Video	2.21	0.11	20.22	P < 0.002	1.05
Lot size					
2-6	5.90	0.10	58.29	P < 0.002	1.17
7-10	8.02	0.10	76.17	P < 0.002	1.18
11-25	9.72	0.20	48.63	P < 0.002	1.06
26-50	10.05	0.29	34.20	P < 0.002	1.07
51-75	10.61	0.32	32.87	P < 0.002	1.06
75+	-7.92	0.06	-114.74	P < 0.002	1.56
Gender					
Heifer	-12.59	0.05	-211.95	P < 0.002	1.12
Bull	1.39	0.12	11.28	P < 0.002	1.29

* Observed significance levels within row (P < 0.05).
[1]Coef = Correlation coefficient.
[2]SE Coef = Standard error of the coefficient.
[3]VIF =Variance inflation factor.
[4]Constants are traditional auction type, lot size 1, steer gender, mix color, and 500-599 pounds weight class.

Regression analysis of bid price for steers 600 to 899 pounds was significant in video, value-added sales, and traditional auction sales (P < 0.05), as shown in Table 23.

Table 22. Regression analysis of cattle bid price in dollars per cwt versus color/ breed influence and weight class in pounds, sold through 2009-2018 at Joplin Regional Stockyards.

Term	Coef[1]	SE Coef[2]	T-Value	P-Value[*]	VIF[3]
Constant[4]	101.11	0.26	386.83	P < 0.002	---
Color					
Unknown	10.72	0.13	78.72	P < 0.002	1.27
Black	0.317	0.06	4.76	P < 0.002	1.34
Charolais	-0.21	0.11	-1.95	P = 0.051	1.13
Black white face	-0.72	0.20	-3.61	P < 0.002	1.05
Red	-3.88	0.11	-33.91	P < 0.002	1.13
Simmental cross	-7.27	0.76	-9.50	P < 0.002	1.00
White	-8.83	0.24	-36.27	P < 0.002	1.03
Brahman	-48.72	1.27	-38.44	P < 0.002	1.00
Weight Class					
350-399	18.78	0.10	174.97	P < 0.002	1.21
400-499	10.92	0.07	147.46	P < 0.002	1.43
600-699	-9.96	0.08	-122.60	P < 0.002	1.35
700-799	-17.70	0.10	-172.39	P < 0.002	1.24
800-899	-24.96	0.14	-176.90	P < 0.002	1.15
900-1,000	-35.59	0.20	-177.47	P < 0.002	1.07

[*] Observed significance levels within row (P < 0.05).
[1]Coef = Correlation coefficient.
[2]SE Coef = Standard error of the coefficient.
[3]VIF =Variance inflation factor.
[4]Constants are traditional auction type, lot size 1, steer gender, mix color, and 500-599 pounds weight class.

Regression model correlation coefficients support that there was a positive effect seen for value-added bid price over traditional auction sales with mean bid price +$5.12 per cwt for value-added and +$1.48 per cwt for video sales over traditional sales. All lot sizes and included weight classes were found to have a significant (P < 0.05) effect on sale bid price (Table 23).

Table 23. Regression analysis of bid price in dollars per cwt versus auction type, lot size, and weight class in steers 500 to 899 pounds sold through 2009-2018 at Joplin Regional Stockyards.

Term	Coef[1]	SE Coef[2]	T-Value	P-Value[*]	VIF[3]
Auction Type					
Value-Added	99.29	0.58	169.89	P < 0.002	---
Traditional	-4.57	0.24	-19.02	P < 0.002	3.39
Video	-2.59	0.27	-9.32	P < 0.002	3.30
Lot size					
2-6	7.13	0.14	50.24	P < 0.002	1.18
7-10	9.52	0.14	67.59	P < 0.002	1.21
11-25	11.05	0.24	45.51	P < 0.002	1.08
26-50	10.44	0.35	29.56	P < 0.002	1.10
51-75	11.68	0.38	30.22	P < 0.002	1.09
1	-8.40	0.10	-78.50	P < 0.002	1.54
Weight Class					
600-699	-11.09	0.09	-113.84	P < 0.002	1.19
700-799	-18.96	0.12	-157.54	P < 0.002	1.19
800-899	-25.62	0.16	-155.22	P < 0.002	1.18

[*] Observed significance levels within row (P < 0.05).
[1]Coef = Correlation coefficient.
[2]SE Coef = Standard error of the coefficient.
[3]VIF =Variance inflation factor.
[4]Constants are value-added auction type, lot size 1, and 500-599 pounds weight class.

Regression analysis of bid price for heifers 500-899 pounds, was significant in value-added, video, and traditional sales (P < 0.05) (Table 24). Regression model correlation coefficients support a positive effect seen for value-added bid price over traditional auction sales. Mean bid price of heifers 500-899 pounds for value-added sales +$3 per cwt, video sales +$1.91

per cwt over traditional sales. All lot sizes and included weight classes were found to have a significant (P < 0.05) effect on sale bid price.

Table 24. Regression analysis of bid price in dollars per cwt versus auction type, lot size, and weight class in heifers 500 to 899 pounds sold through 2009-2018 at Joplin Regional Stockyards.

Term	Coef[1]	SE Coef[2]	T-Value	P-Value[*]	VIF[3]
Auction Type					
Value-Added	87.74	0.51	170.09	P < 0.002	---
Traditional	-2.83	0.21	-13.03	P < 0.002	2.63
Video	-2.26	0.27	-8.39	P < 0.002	2.54
Lot size					
2-6	4.24	0.13	32.45	P < 0.002	1.18
7-10	6.02	0.13	45.94	P < 0.002	1.20
11-25	7.74	0.25	31.00	P < 0.002	1.06
26-50	7.88	0.36	21.62	P < 0.002	1.09
50-75	7.72	0.41	18.42	P < 0.002	1.09
1	-7.10	0.09	-75.60	P < 0.002	1.34
Weight Class					
600-699	-7.62	0.09	-84.45	P < 0.002	1.13
700-799	-13.94	0.11	-118.31	P < 0.002	1.14
800-899	-20.70	0.16	-122.84	P < 0.002	1.07

[*] Observed significance levels within row (P < 0.05).
[1]Coef = Correlation coefficient.
[2]SE Coef = Standard error of the coefficient.
[3]VIF =Variance inflation factor.
[4]Constants are value-added auction type, lot size 1, and 500-599 pounds weight class.

DISCUSSION

Data in this study encompassed 3,400,621 cattle sold between March 2009 and December 2018 at Joplin Regional Stockyards through value-added, video, or traditional feeder sales. The findings of this study showed 90 percent of feeder cattle were sold through traditional auctions whether it be steer, heifer, or bull. However, regression model correlation coefficients supported a positive effect for video and value-added bid price over traditional auction sales. Mean price paid per lot of feeder cattle was lowest in the traditional auction \$147.13 per cwt, with the mean bid price of value-added \$148.13 per cwt, and video sales \$153.49 per cwt. In limiting analysis to 500 to 899-pound cattle of separate genders value-added mean bid price was higher than video auction, but both pre-conditioning marketing techniques were superior to traditional sells in mean bid price returns. This suggested that while traditional auction sales may be the most popular the results of this study suggest it is beneficial for producers to sell cattle in either video or value-added sales. The study agreed with previous research that indicated value-added cattle on average received higher prices than those sold through traditional auctions due to value-added and video sales requiring cattle to go through additional pre-conditioning practices such as pre-weaning and health programs, ensuring cattle are more attractive to buyers (Zimmerman, et al., 2012).

All auction types were found to have a significant effect ($P < 0.05$) on sale bid price. Cattle sold through video sales had a higher overall mean bid price than cattle sold through traditional sale auctions encompassing all weight classes. Several factors could contribute to this higher mean price seen across the almost ten years of data. Video sales provide feedlot managers the opportunity to purchase large lots of cattle that will gain at a similar rate (Avent et al., 2004).

As discussed in the literature review, seller reputations also influenced the price as cattle sold through video sales are shipped directly from producer to buyer and are therefore at a reduced risk of respiratory disease when compared to cattle commingled from different backgrounds at traditional sales. Cattle sold through video sales are often from larger ranch operations that have health protocols for cattle. Although these cattle are not sold as part of a value-added sale, the majority have received preconditioning protocols similar to value-added cattle (Mintert et al., 1990; Zimmerman et al., 2012). Expected price per cwt was found to decrease as feeder calf weight increased with weight classes having a significant effect ($P < 0.05$) on bid price. When looking at results for steers and heifers of 500-899 pounds, value-added sales sold for more than traditional sales and video sales. Mean bid price of steers 500-899 pounds in value-added sales were $5.12 per cwt more than those from traditional sales and $3.64 per cwt more than video sales. In heifers 500-899 pounds value-added sales sold for mean bid of $3.83 per cwt more than those for traditional sales and $1.09 per cwt more than video sales. These findings are supported by other previous studies that found value-added sales earn price premiums over traditional auctions (Avent et al., 2004; King, 2002; King et al., 2006, Seeger et al., 2011, Zimmerman et al., 2012).

In this study steers consistently earned higher bid prices than heifers and bulls across all auction types. Gender was found to have a significant ($P < 0.05$) effect on bid prices. This is supported by previous research that states steers receive premiums at auction in comparison to bulls and heifers (Barham and Troxel, 2007; Harborth et al., 2010; Schroeder et al., 1988). Steers are more valuable to stocker cattle or feedlot producers for several reasons. Time spent on breeding behavior by cattle limits their feed intake and wastes energy that could be used for growth. Steers also have an average daily gain that is higher than that of heifers, making them more valuable to feedlot producers (Zimmerman et al., 2010). Premiums for steers over bulls represent part of the feedlot's reduced risk of death loss, as male cattle castrated at higher weights have an increased risk of death loss from infection and blood loss (Russell, 2015). Discounts for bulls within this study may differ as a higher percentage of bulls were found to be in lighter weight classes of under 25 cattle. A study by Cleere and Boleman (2005) found discounts for bull calves increase as an animal's weight increases to allow for shrinkage and possible death loss from castration.

Lot sizes containing 75 or more cattle compromised the largest percentage of cattle sold in value-added and video sales. In traditional sales lots of 11-25 cattle made up the largest percentage, a similar study at JRS found the average lot size to be 10.3 cattle (Harborth, et al., 2010). All lot sizes were found to have a significant ($P < 0.05$) effect on sale bid price. Lowest mean bid prices were found in steers $141.68 per cwt and heifers $135.32 per cwt in lots containing 50-75 cattle. Lots of 50-75 cattle also had the heaviest mean weight of 756.70 pounds and included cattle from all sale types. For bulls the lowest mean price of $153.32 was in lots containing 2-6 calves, with too few lot sizes of over 25 bulls for the findings to be significant. When all categorical variables are considered, lot size itself may not be the cause for the price difference. Smaller lot sizes are often made up of lighter weight calves, causing average sale prices to decrease as weight category increases. In this study for instance, the average weight per cattle in lot sizes of one was 549.96 pounds and 756.70 pounds in lot sizes of 50-75 cattle. When separating cattle by weight class, previous research has shown a larger premium for larger lot sizes of cattle than was found in this study. In agreement with previous research, the results of this study indicate feeder cattle prices decline as feeder cattle weight increases (Dhuyvetter and Schroeder, 2000, Harborth et al., 2010, Peel and Meyer, 2002). Overall mean bid price premium increases for steers \$49.68 per cwt, heifers \$44.79 per cwt, and bulls \$90.74 per cwt as the studied weight class decreases. In agreement with other studies (Blank et al., 2009; Dhuyvetter and Schroeder, 2005; Harborth et al., 2010; Schroeder et al.,1988) weight variation was a statistically significant price determinant in feeder calves.

Cattle of mixed breed/color were the most common in the study followed by black cattle. In this study unknown color was comprised primarily of cattle sold through video sales, as color description was not captured in the data set. Cattle in video sales are typically sold in lots of uniform color and size, thus influencing bid price. Most of the color/breed influence in the study had a significant ($P < 0.05$) effect on the bid price, except for Charolais which was not significant ($P = 0.051$). Color/breed were found to be statistically significant in previous literature (King, 2002; King et al., 2006; Harborth et al., 2010; Smith et al., 2000).

Limitations

This study data set did not capture any pre-conditioned cattle sold through traditional feeder auction and that could lower the price premium difference between value-added and traditional auction types. As this study encompassed almost ten years of data some errors are expected. Less human error may be achieved with organized procedures and the precise execution of such procedures. Regression models have been used in previous studies for cattle pricing data as have hedonic pricing models. Hedonic models navigate through the layered effects of management strategies that could affect multicollinearity and consider the effects of corn and cattle futures on the cow-calf market (Harborth et al., 2010; Lambert et al., 1989; Minert et al., 1990; Sartwelle et al. 1996; Schroeder et al., 1988; Zimmerman et al., 2012).

Hedonic modeling could help further differentiate economic benefits of pre-conditioning for the producer.

CONCLUSIONS

Previous studies have established that cattle sold through value-added marketing have the potential to earn premiums at sale time. However, it was unknown whether differences in bid prices existed between traditional, value-added, and video sales at a single sale barn. This study was specifically interested in the cost benefit of value-added sales and video sales as it relates to animal welfare practices. Based on the literature review it was predicted that calves raised and marketed in Southwest Missouri under more intensive management programs with verified health claims would receive a higher sale price than cattle without characteristics associated with more advanced herd management programs. The study achieved this through analyzing feeder cattle influence on market price in value-added, video, and traditional auctions and quantifying price premiums for marketing strategies of video or value-added sales over traditional sales. This study confirmed along with previous research, that over time value-added and video cattle will consistently bring in higher bid prices when compared to cattle at traditional auctions. Video and value-added sales may not be practical for all cattle producers due to the earlier mentioned marketing requirements for both sale types. However, producers that take part in value-added management and marketing opportunities were likely to receive a higher price for their cattle than those sold through traditional auctions.

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