ASSESSING THE IMPACT OF THE COVID-19 PANDEMIC ON FEEDER CATTLE PRICES IN NORTHEAST TEXAS

A Thesis

by

KELLEY SMITH

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Approved by:

Advisor:	Jose Lopez
Committee:	Robert Williams Rafael Bakhtavoryan
Head of Department:	Douglas LaVergne
Dean of the College:	Randy Harp
Dean of the Graduate School:	Jennifer L. Schroeder

ABSTRACT

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Kelley Smith, MS
Texas A&M University-Commerce, 2022

Advisor: Jose A Lopez, PhD

Beef is a prominent commodity in the United States, even though it is understood that the covid pandemic has affected the beef industry. This study attempts to quantify its effect on feeder cattle prices in Northeast Texas. There are several different stages from farm to fork within the beef industry (cow-calf operations, feeder cattle, stockers, etc.). One that serves as a solid component for the longevity of the beef industry is preconditioned cattle sales. Preconditioned cattle seem to be a less risky and better suiting market to some feedlots which can also bring a competitive nature in the auction ring dependent upon characteristics such as breed, weight, and gender. Ultimately this study concludes that there was a difference among prices from before, during, and current covid standings of the NETBIO auctions in Northeast, Texas.

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INTRODUCTION

Many industries and product lines were severely impacted by the Coronavirus disease 2019 pandemic, commonly referred to as covid (Balagtas and Cooper, 2011). The threat of contracting the virus was a fear of everyone. The isolation from schools and some jobs also put a strain on the everyday tasks with businesses and many functions around the world. However, the food industry, and within it the beef industry, endured through these struggles along with many other industries. The feedlots and packing houses were forced to conform to the guidelines and restrictions that were brought on from the pandemic. Although there were some setbacks caused by covid, the food industry persisted in order to meet the demands set forth by its consumers. Griffith and Martinez (2020) reported many uncertainties attributed to the pandemic pertaining to feeder cattle prices. They also found downward trends in the amount of cattle being sold during the first quarter of the year 2020.

Cattle and beef production are top commodities across the country (Trupo, 2021). According to the United States Department of Agriculture (USDA-FAS, 2021) and Trupo (2021), the United States is the world's largest beef producer and ranks second in imports and third in exports (USDA-FAS, 2021). The United States experienced a steady increasing trend of beef exports from 2016-2019, however they experienced a 6% export decrease from the year 2019-2020, on count of trade barriers and export restrictions due to the pandemic (Troup, 2021). Many consumers often choose beef over other meat varieties. The beef industry is commonly split into two sectors, cow-calf operations and feedlot operations with preconditioned sales being the merging point of the two sectors.

Covid has brought challenges to the beef industry and the partners who are involved. Cattle sales and auctions have endured the uncertainty of the markets, and more specifically preconditioned sales have prevailed. In Northeast Texas, a preconditioned calf sale known as North East Texas Beef Improvement Organization (NETBIO), is utilized by many farms and ranches within the area as well as numerous counties throughout Texas and several other southern states. NETBIO holds numerous calf sales each year for producers to market their cattle to bigger feedlot operations. The sale is designed specifically to appeal to serve feedlots. The NETBIO closes the communication gap between feedlots and local producers. In addition the NETBIO also opens the door to premium price efforts for the producers, simply because the feedlots are able to purchase more from a quantity perspective which entices them to pay the price. The cattle are weighed and classified by color, sex, and breed upon arrival. After they are classified, they are assigned to lots with other cattle that have the same attributes. This allows the lots to have anywhere from 1 to 100 heads depending upon total weight of the lot. Each lot has a description that summarizes the type of cattle that accompanies the lot. For example, the term "Exotic" is used to reference breeds of cattle such as Limousine, Simmental, and Charolais. "Okie" is used to reference Hereford, Angus, and Red Angus Breeds (NETBIO, 2021). Numbers are also used to indicate, Brahman influenced cattle. Lastly the term "feeder" is used on some lots to express the weight of 650 pounds or higher (NETBIO, 2021). Another appealing aspect of these cattle is the requirements that must be met in order for them to be eligible for the sale also known as pre-conditioned. The cattle must undergo a series of vaccines for black leg, respiratory viruses, worms and any other bacteria. The cattle also require a booster 30 days prior to the sale as part of the system. Bull calves must also be castrated and fully recovered by sale date. Lastly the cattle must be dehorned and display a NETBIO ear tag in the left ear. Adding

these management practices to the cattle develops credence to the buyers view. (Williams, 2012). The visible practices like dehorning and castration are seen; however, to ensure that other requirements such as vaccination and weaning protocols are met, the NETBIO provides a veterinary verification form to be complete. In considering the pandemic with many companies' enforcing regulations on face-to-face interaction, NETBIO also offers an online bidding system. This help to alleviate some of the pressure to promote buyer participation. Upon completion of the sale, these cattle are shipped to feedlots all across the Midwest and central United States to serve packing houses. Preconditioning theses cattle for the sale inhibits added value.

Above all else, it is evident that the pandemic has brought on new challenges and triumphs. The beef industry is built on a solid foundation with a drive to successfully fulfill consumer demands. With the high demand for beef not only across the nation but across the world, it is imperative the industry performs at the most effective and efficient level to satisfy the continuously growing demand. This study will assist feeder cattle producers, beef organization, ranchers, and feedlots in understanding the impacts of the covid-19 Pandemic on current trends that have emerged as a result of the pandemic.

Statement of the Problem

Calf sales, like the NETBIO, would not be possible without the buyers, sellers, and all final beef consumers across the industry. The industry requires coordination among food processors, truckers, and feedlot personnel to manage the cattle to get them to reach the ending goal. With the threat of covid lurking, many personnel that served in this process were or could have been hit with the viruses causing them to be unavailable, in turn causing gaps or delays in the cattle industry. Although the beef industry has prevailed through these difficult times, this study assesses how the covid pandemic has impacted NETBIO preconditioned calve sales.

Purpose of the Study

The purpose of this study is to determine how the covid pandemic has affected preconditioned cattle sales in Northeast Texas through the NETBIO program. NETBIO classifies its cattle according to weight, color, breed, gender, and lot number. This study will utilize these attributes to statistically analyze the effect of the covid pandemic on sale prices. This will be beneficial to producers in and around Northeast Texas in order to represent the undertaking of the virus on cattle prices.

Objectives

Utilizing analysis of variances to evaluate price fluctuations centered around the effect of the pandemic, the study will concentrate on the following objectives:

1. Relate literature to the analysis of prices of NETBIO sales during the covid Pandemic.
2. Discuss impressions of price differentials on producers.

Hypothesis

The hypothesis of this study is that there will be a significant difference between the prices of the years 2019, 2020, and 2021 during the month of September at the NETBIO auction, in account of the covid-19 pandemic.

Significance of the Study

The vast uncertainty that the covid pandemic has brought on has spread throughout many industries and can be difficult to define. There is an increasing amount of research highlighting the economic effect of the virus. This study will serve as a reference point highlighting the economic effect of the virus on preconditioned feeder cattle sales, benefitting producers and industry representatives that could use this information to evaluate and adjust their financials standings on account for covid.

Definition of Terms

Pre-conditioned-The backgrounding of cattle by performing a series of vaccinations, dehorning, and other regulatory health maintenance and record keeping.

Commodities- Resources that can be utilized by transformation into a consumable use.

Feeder cattle-Cattle to be put on feed to gain weight for the specific goal or being processed.

NETBIO-Northeast Texas Beef Improvement Organization which strives to promote beef improvement through facilitating the preconditioned sales.

Limitations

Limitations that are surrounding the study are as follows:

1. The NETBIO data used in the study are limited to the month of September for three consecutive years of 2019, 2020, and 2021.
2. The NETBIO data could carry unknown human errors.

Delimitations

The following delimitations are present within the study:

1. Characteristic and traits such as lot, weight, breed, and gender are specified and predetermined as set forth by NETBIO personnel.
2. The Northeast Texas Beef Improvement Organization sale is conducted in partnership with Sulphur Springs Livestock Auctions. Although there are additional sale barns in the surrounding area, this study is focused on the NETBIO sales.

Organization of Thesis Chapters

Chapter 1 provides a background and introduction of the study and also describes the nature and process of the Northeast Texas Beef Improvement Organization. Chapter 2 examines relative literature that has both similarities and differences compared to this study. Chapter 3

explains the procedure of the study as well as the models used. Chapter 4 presents the results derived from the models. Lastly chapter 5 reveals the summary and conclusions of the study.

Chapter 2

REVIEW OF THE LITERATURE

With the continuation of the threat of coronavirus, the world is adjusting to what will likely be the new normal. Since the pandemic started, there has been minimal research on the commodities that have had an. Balagtas and Coopers (2021) discuss some key points that have been discovered in regards to covid-19's impact on livestock markets. First, there was a direct spike in grocery sales during the first few weeks of the pandemics arrival. Simultaneously, restaurant and travel spending took a complete downward dive at the exact same time, since a national emergency was proclaimed and everyone was advised to stay home. More than just grocery trends, Balagtas and Coopers (2021) delve into looking into commodities that were imprinted by the virus. Although the virus brought many challenges, the meat industry was supported by the president, as he ordered that the meatpacking plants remain in production through the defense protection act. In the early stages of the pandemic the wholesale value of beef and pork had increased while the gross farm value of beef and pork stayed constant. The reasoning behind this was due to the shutdowns and regulatory measures of employee exposure that led the sparse availability in the packing of live animals. This also left "decreases in the supply of prepared meat to enter the wholesale and retail markets" (Balagtas and Cooper, 2021). While an increase in demand was sure to bring an increase in prices, the consumer price index (CPI), for meat alone rose 9%, which is larger than any other commodity. However, it was not till a couple months after the initial start of covid, that the CPI's started to rise, this could be due to the fact that the spread was happening so efficiently and brought down more personnel in the production line. In contingency, Balagtas and Coopers (2021) examined more sectors of the meat supply chain through its model. The model itself exhibits a relationship between retail meat

prices, livestock prices and also includes a marketing factor. The ideology that the paper explains is the retail cost of the meat is comprised of both the price livestock and the marketing component. Balagtas and Cooper's (2021) model produces an intuitive equilibrium relationship between meat prices and livestock prices:

$$P_{meat} = P_{livestock} + M, \quad (2.1)$$

where P_{meat} represents the retail price of meat, $P_{livestock}$ the price of livestock and lastly, M is the marketing Margin (Balagtas and Cooper, 2021). With meat packers incurring additional cost to inhibit virus contraction and providing safety measure this raises the price even more. There has been some speculation as to if the meat packing participants choose to use the pandemic as an opportunity to raise margins in an effort to raise competitiveness and increase market power. Although this remains to be undefined, the resiliency of the industry has remained throughout which is telling in the way that the virus constrained many other industries. The meat industry would be one that most would consider vulnerable to health and safety regulatory measure which is accurate but even through the pandemic the demand for meat and feeding people will always drive the market and continue to bring the industry to new heights. The model used is simple yet functional to describe the relationship between meat prices and livestock prices. Similarly to this study, the model will simply express characteristics and their relations to price. The last portion of the paper discusses trade. Even though trade restrictions and exports brought price reductions domestically, it also created supply shortages in the long run and put a damper on the trade economy. Overall Balagtas and Coopers (2021) brings to light the unnoticed "upsets" to the meat and livestock industry that arose from the covid pandemic, while keeping in mind that the virus and the pandemic combined has not ended, the industries have adapted to the circumstances.

Additionally, Hardin and Saghaian (2014) present a model that is kindred to this study. Their study focuses on the seasonality of feeder cattle. Balagtas and Cooper (2021) and Hardin and Saghaian (2014) carry many of the same attributes especially in regards the models. Hardin and Saghaian (2014) utilizes the following model:

$$CPH\ price = B_0 + B_1\ Lot\ Size + B_2\ Lot\ Size^2 + B_3\ Weight + B_4\ Live\ Futures + B_5\ Corn\ Futures + B_6\ Diesel\ Price + B_7\ Heifer + V_8\ Season + V_9\ Cattle\ Sort + B_{10}\ Time, \quad (2.2)$$

where CPH represents the Certified Preconditioned Health program. Parallel with the model of this study, both examine factors such as lot size, weight, and gender to derive the price. These models are interchangeable in format of each of the studies and create functionality within the study, by incorporating variables that are suiting to the nature of the study. Another similarity between the two studies is that they use the least squares regression to compute the results. The ideas presented by Hardin and Saghaian (2014) provide an extensive idea to producers of all the external factors that are involved in the cattle industry. Their study serves as a firm foundation relative to the one presented.

Similarly, Bankole (2017) produced a study that also examines data from the NETBIO sales in twenty ten through twenty-thirteen. Their study focused on the attributes that significantly "added the most value" (Bankole, 2017), also including and comparing the futures market to explain the variation among the feeder cattle prices. Bankole utilized the following model:

$$Pcasht = \beta_0 + \beta_1\ Lot_t + \beta_2\ Sex_t + \beta_3\ WT_t + \beta_4\ Breed_t + \beta_5\ JanuaryFutures + \beta_6\ MarchFutures + \beta_7\ AprilFutures + \beta_8\ MayFutures + \beta_9\ AugustFutures + \beta_{10}\ SeptemberFutures + \beta_{11}\ OctoberFutures + \beta_{12}\ NovemberFutures + \beta_{13}\ Lot^2_t + \beta_{14}\ WT^2_t + u_t. \quad (2.3)$$

Equation (2.3) is similar to the model used in the present study with the exclusion of the futures

variables. The model conducts a close comparison between the futures market prices to that of the preconditioned cattle sales with the addition of other influence variables. The study found that weight, sex, lot size, breed, and futures price add had a statistical significance. Additional discoveries were a "unit gain in weight established a slight discount, heifers also were discounted when compared to steers, and lastly English or okie breeds collected premiums over crossbred cattle" (Bankole, 2017). The study also concluded that the futures price and cash price had a positive association while the October futures contract inhibited a push in cash prices. In alignment with this study being conducted the month of October create the pivotal time of the year where producers are purging their cattle in preparation for the season change.

Moreover, Agustin (2021) studies trends within the cattle industry from Nicaragua. A hedonic model is utilized to analyze price differentials from futures feeder cattle prices derived from the Chicago Mercantile Exchange as well as supplemental data of cattle auctions in Nicaragua from the year twenty seventeen and twenty eighteen (Agustin, 2021). His model was:

$$Basis_{it} = \beta_0 + \beta_1 Lot_{it} + \beta_2 Lot_{it}^2 + \beta_3 Weight_{it} + \beta_4 Weight_{it}^2 + \beta_5 Heifer_{it} + \beta_6 Bull_{it} + \beta_7 February + \beta_8 March + \beta_9 April + \beta_{10} May + \beta_{11} June + \beta_{12} July + \beta_{13} August + \beta_{14} September + \beta_{15} October + \beta_{16} November + \beta_{17} December + \varepsilon_t. \quad (2.4)$$

Equations 2.4 encompasses many similar components to Bankole's study as well as the present study. Similar to the previously discussed studies, Agustin's (2021) also identifies factors that influence price differences. They also note that Nicaragua's cattle industry is non-intensive and exhibited 24% growth within those 2 years (Agustin, 2021). In parallel with Bankole's (2017) study, results indicated that characteristics such as weight, lot size, and sex of the cattle at the auction were statistically significant in the price differences. Agustin's (2021) study aims to achieve the common objective of the present study by helping producers understand the factors

that influence cattle prices at auction, which will aide them in their operational decision making in the future.

University of Tennessee in conjunction with their extension service produced two reports by Griffith and Martinez (2020, A). The first report extensively discusses the marketing factor that is taken into consideration when producers are making plans to sale the cattle. There can be many components or external factors that influence producer's decisions to sell. The first being weather, harsh weather conditions such as rain, sleet, or snow make maneuvering as well as loading and unloading the cattle to and from the sale barn difficult. The Report from the University of Tennessee claims that factors such as these are "short-lived", and producers are typically able to bounce back with a few weeks Griffith and Martinez (2020,A). Weather does bring a small decrease in prices, but the market is quick to overcome and retain its earrings. However, conditions such as the Corona Virus and pandemic brought a wealth of unknown to producers and made future plans to sell difficult to make, as the depressed market prices did not have an end in sight. The report continues by exceptionally explaining that cattle are "perishable products" by continuously growing and must enter the supply chain that is urgent to the beef industry (Griffith and Martinez, 2020 A). Similarly, to the NETBIO calves considered in this study when submitted for sale, have a goal ahead to meet the industry's needs. With the unknown of price deflects brought on by the pandemic, producers will be willing to ensure the highest of profits when marketing their cattle by enlisting their cattle into preconditions sale like NETBIO, in hopes of receiving a higher premium. The report exemplifies total head counts of cattle sold in the auctions of Tennessee during the first quarter of the last 5 years leading into and including the pandemic. The first figure represents feeder cattle, the year 2020 alone is interesting to examine being that counts maintain a downward slope leading into the pandemic.

It's much thought provoking to wonder if this is due to seasonality effect or the initial precautions of covid or a combination of the two.

The second report from the Griffith and Martinez (2020, B) delves into the feeder cattle prices and their affects from covid. An interesting point covered in this report is the seasonality of the cattle market. They explain the intricacy of the seasonal planning that is used in most cattle operations. Most cattle producers calve in the late winter and early spring time in light of the spring grasses that are rich and nutritious and helping enhance the calves growth and development. These producers will prefer to market these cattle in the fall before weather conditions turn undesirable. Although there is some fluctuation in prices between the season because of the operating factors and influx of participation of the seasonality. To be more specific, prices fall slightly in the fall because of the heavy supply and the prices will rise in the spring when market participation is lower (Griffith and Martinez, 2020 B). Towards the end of the report is the telling point. Figures are used to express the change in prices over the months dated back a decade leading into covid. Both figures show a dive in prices in the early month of 2020 for 500-600 pound and 700-800 pound steers that are substantially lower than any other point in time represented on the graph. This reasoning behind it is backed with the uncertainty and increased cost in all sectors of the supply chain.

Williams, (2012) conducted a study that determined the price differentials of value added feeder cattle at various auctions in Oklahoma. This study examines a program that is similar to NETBIO and has the same preconditioning requirements known as Oklahoma Quality Beef Network (OQBN). The OQBN also facilitates regular feeder cattle sales that do not require preconditioning. This study considers the impact of preconditioning and investigates factors that affect price differentials. Williams, (2012) Data was collected at sixteen feeder cattle auctions

across seven different sale barns over the course of three months for a total of 2,973 lots. Eight of the sales acquired some OQBN preconditioned sales, six were a combination of OQBN preconditioned and regular feeder calves, and two were strictly OQBN preconditioned certified auctions. The study analyzes the price and variable influence of each. The variables included color or breed, presence of horns, use of vaccinations, OQBN Certified, gender, fleshing condition, muscling, and uniformity. Williams (2012) uses the following hedonic model to evaluate each lot and the presence of each variable:

$$\textit{CPH price} = B_0 + B_1\, \textit{Lot Size} + B_2\, \textit{Lot Size}^2 + B_3\, \textit{Weight} + B_4\, \textit{Live Futures} + B_5\, \textit{Corn Futures} + B_6\, \textit{Diesel Price} + B_7\, \textit{Heifer} + V_8\, \textit{Season} + V_9\, \textit{Cattle Sort} + B_{10}\, \textit{Time}. \quad (2.5)$$

Results revealed that most of the variable were significant at 5% except for the relation between certification and weight (Williams, 2012). As expected, black-hided lots receive a higher price/cwt than all other hide colors because of the potential for acceptance in the Certified Angus Beef program, which serves as a commonality and trend across all auctions. The variables fleshiness, frame, muscling was not proven statistically significant from the model. Overall, the study revealed that calves with vaccinations alone receive a premium of $1.44/cwt ($p = 0.018$). Ultimately cattle that are enrolled and are OQBN certified received a higher price compared to the non-preconditioned cattle that were observed (Williams, 2012).

Covid Timeline

According to the CDC, Center for Disease Control and Prevention, covid began to appear in December of 2019 in the country of China where many patients began to experience a shortness of breath and fever (CDC, 2022). The World Health Organizations China division was then informed of the cases of so called “pneumonia” with unknown causes. By the first couple

weeks of 2020, the CDC began to identify the “causative agent” (CDC, 2022) that produced the outbreak and began the screening of people who had traveled from Wuhan, China, where the virus was first discovered, to cities with connecting flights. A few of these cities include New York, Los Angeles, and San Francisco. USA Today by Hauck (2020) reports that the first covid case in the United States was found on January 21, 2020, from a man who recently travel back from Wuhan, China one week before. (Hauck, 2020). From here the next few weeks to a month entailed testing development along with federal organization of research on the virus and its contagiousness. On March 13, 2020, President Donald Trump announced a nationwide emergency declaration (CDC, 2022). It was not but just a day or two until the whole country was on a shutdown or commonly referred to as the stay-at-home mandate. At this point many people were uncertain about the near future and the everyday functions of society. The mask order was also enforced at this time. As time progressed cases of covid began to increase hitting a record 100,000 by the end of May (CDC, 2022). In addition, unemployment rate rose to 14.7 percent, which had not been seen since the great depression (CDC, 2022). As the year pressed on many mile markers within the pandemic were established. Many trials and research regarding vaccines Cases continue to increase along with the death toll reaching 200,000 by the end of September (CDC, 2022). By the end of the year the vaccines had been put into production with not only one but two types of vaccines and began being administered under certain qualifications. Before January 1, 2021, over a million vaccines had been administered (CDC, 2022). Additionally, congress passed a covid relief act that would provide an allowance of $600 per individual. Shortly afterwards with more popularity and acceptance towards the vaccine there began to be a shortage amongst available vaccines. The first quarter of 2021 still inhibited many regulations and covid practices however some operations began to return to a new normal. For instance,

events were held outside or in spaces that could accommodate social distancing, mask were required in most public areas, and schools returned to in person instruction the previous fall with new regulatory standards. Although cases still continued to rise normalcy was still able to evolve as more and more people were receiving the vaccine to combat the widespread. By the middle of the year and early summer the Delta variant was profound. By the end of the summer 2021, vaccines were ready and approved for all adults and people above sixteen years of age (CDC, 2022). As the year 2021 came to an end, covid was still very much around; however, society was used to its existence and were able to overcome. The vaccines helped to slow the spread and obtained a grasp on the virus as a whole. The study from the Annals of Palliative Medicine by Lu (2021), analyzed all aspects of the pandemic and was categorized it into three phases. The first phase "Intensive Attention on Wuhan" (Lu, 2021) is centered around the initializing of the virus and the implementation of preventive actions such as the lockdown and travel ban in order to "delay the growth of the epidemic" (Lu, 2021). The second phase was described as "internal stability but a threat from abroad" (Lu, 2021), which focused specifically on isolating the threat of contraction from abroad with strict quarantine protocols. The last phase "prevention and control of imported goods and the economic recovery" (Lu, 2021) assessed the control from an economic standpoint.

Variants

Over the course of the pandemic many variants of the virus were discovered and continue to be researched over. Yale Medicine article by Katella (2022), reports on each variant and describes their known arrival time as well as their severity and contagiousness. The first variant described is Omicron and B.A.2 which is known as the sub variant to Omicron (Katella, 2022). According to Katella (2022), Omicron was developed around the later end of 2021.Omicron also

was one of the more transmissible variants as cases tended to “skyrocket” (Katella, 2022) and produce a few thousand cases per day. Katella (2022) also reports that because its placement and attachment of cells it allows it to be more infectious, however even though it is sought to be very contagious it is also “appears to be less severe” (Katella, 2022) then other variants. Delta is the next variant that Katella (2022) discusses, they report that Delta was first identified around the end of 2020 and caused “more than twice” as many more infections along with a surge in hospitalizations. The report also notes that the severity of the variant may be due to the fact that many had been unvaccinated around the time of know existence. Another strain of the Delta variant is also reported as Delta AY.4.2. While the report states that data regarding this variant is “limited” (Katella, 2022), it is still as much if not more contagious and rigorous as Delta. The next variant discussed from the Yale Medicine (2022) report is Beta, which was first endured at the end of 2020 from South Africa. Katella (2022) explains that while Beta was “about 50% more contagious, it also may have led to more hospitalizations and deaths”. Lastly the Alpha variant is described to have appeared in November of 2020 and is believed as the most contagious accounting for 66% of cases of the covid strains until deltas arrival.

Chapter 3

METHOD OF PROCEDURE

Data Gathering

The NETBIO sale is facilitated once a month on approximately nine months out of the year at Sulphur Springs Livestock Auction (SSLA). Each lot has corresponding variable characteristics such as breed, total weight of the lot, average weight for each head in that lot, and ultimately the price per hundredweight (cwt) that each lot sold for. Data and variable characteristics on the preconditioned cattle were obtained from the particular months of September from the years 2019, 2020, and 2021. Twenty nineteen is the year prior to covid's initiation. Twenty-twenty is the initial year of covid's existence and twenty twenty-one is the most current. Although covid arose in the early months of the calendar year, September is a highly desired month to consign cattle for the NETBIO sale. In addition, the fall season is a pivotal time for ranchers to sell cattle. The reason for high volume of participation during this month is because of the turning point between seasons. With the change in weather soon approaching during this time, many producers prefer to sell rather than hold the cattle over the winter, where threats such as sickness and cost of inputs and resources, like hay are present. With this I feel that it was appropriate to examine sales data from September.

A covid variable will be assigned to each sale in the respect of the timing that the sales occurred and in accordance with known covid variants. To further explain, 2019 sales data will be assigned as 0 to the covid variable to indicate that covid had not yet arrived. Sales data from 2020 will be assigned a 1 to the covid variable to show that covid was in the first year of initialization and that minimal information was known about different variants. Lastly, 2021 sales data will receive a 2 on the covid variable scale to demonstrate the vast number of cases happening as well as the several known variants of covid.

Models

This study will utilize and compare two models estimated through SAS software version 9.4 to determine the effects of covid-19 on feeder cattle prices. The first model is the separate means ANOVA model while the second model is a multiple regression model.

ANOVA model

In the first model, this study will use a one-way ANOVA approach to analyze the mean differences among prices from various stages within covid pandemic. The model will be used to analyze the effect of the covid pandemic on preconditioned feeder cattle prices. The separate means ANOVA population model is as follows:

$$Y_{ij} \sim \mu_i + \epsilon_{ij}, \tag{3.1}$$

Where μ_i is the mean of each group, and ϵ_{ij} is the term that represents independent, normally distributed errors, i is the treatment group number, and j is the response number associated to the treatment group. The sample model is: $Y_{ij} \sim \bar{y}_i + \hat{\epsilon}_{ij.}$ Specific to this study, the treatment groups are the covid presence indicators previously discussed. Therefore, the estimated sample models for each year would be:

$$Y_{2019} = \bar{Y}_{2019} + \hat{\epsilon}_{2019},$$

$$Y_{2020} = \bar{Y}_{2020} + \hat{\epsilon}_{2020}, \text{ and} \tag{3.2}$$

$$Y_{2021} = \bar{Y}_{2021} + \hat{\epsilon}_{2021}.$$

More specifically

$$Y_{2019} = 135.80 + \hat{\epsilon}_{2019},$$

$$Y_{2020} = 135.61 + \hat{\epsilon}_{2020}, \text{ and} \tag{3.3}$$

$$Y_{2021} = 144.44 + \hat{\epsilon}_{2021}.$$

Regression Model

The multiple regression population model is as follows:

$$P_{casht} = \beta_0 + \beta_1 Avg + \beta_2 Sex_t + \beta_3 Y20 + \beta_4 Y21 + u_t. \quad (3.4)$$

The variable *Avg* represents the average weight of the cattle in the lot. Different from Augustin (2021) and Bankole (2017), average weight better suited this study as it accounted for each head individually and alleviated multicollinearity in the variables *TotalWeight* and $TotalWeight^2$. *Sex* is the sex of the marketed cattle. In conjunction with Agustin's (2021) and Bankole's (2017) the variable sex is assigned a dummy variable of 1 for heifers and 0 for steers therefore, steers are excluded from the model to avoid perfect multicollinearity. The variables *Y20* and *Y21* are binary dummy variables for the years 2020 and 2021 respectively, as they relate to covid. The variable *Y19* which would correspond to the year 2019 is the excluded dummy variable from the model to avoid the problem of perfect multicollinearity. The variable Y19 was excluded to make comparisons to when covid had not yet initiated and serves as the baseline. Last, the variable u_t serves as the error term.

Descriptive Statistics

From the obtained data, 447 lots were collected among the three sales to serve as 447 observations, encompassing a total of 14,941 head total. Steers accounted for 8,220 heads or 55.01%, while heifers were represented 6,721 heads or 44.9%. Additionally, 4,625 head were auctioned in the September 2019 sale, 5047 head were auctioned in the September 2020 sale, and lastly 5,269 head were auctioned at the September 2021 sale.

Table 3.1 Descriptive Data by Year of the NETBIO September Sales at SSLA.

September 2019

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT(lbs.)	4625	28618.86	13505.70	583.00	59398.00
AVG(lbs.)	4625	583.37	120.02	227.00	1103.00
Price($/cwt)	4625	135.80	13.37	40.00	180.00

September 2020

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT(lbs.)	5047	31900.19	14867.42	652.00	69597.00
AVG(lbs.)	5047	593.75	124.33	249.00	1105.00
Price($/cwt)	5047	135.61	12.59	50.00	208.00

September 2021

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT(lbs.)	5269	32146.74	19501.37	358.00	101100.00
AVG(lbs.)	5269	614.40	149.32	231.00	1063.00
Price($/cwt)	5269	144.44	14.31	60.00	206.00

Overall

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	14941	30971.40	16361.61	358.00	101100.00
AVG (lbs.)	14941	597.82	133.07	227.00	1105.00
Price($/cwt)	14941	138.78	14.09	40.00	208.00

As it can be observed in Table 3.1 above, the minimum price is at a steady increase between the three sales. Additionally, In September 2019 the prices ranged from $40/cwt to $180/cwt. In September 2020, feeder cattle prices ranged from $50/cwt to $208/cwt. In September 2021, prices ranged from $60/cwt to $206/cwt. The September 2021 sale experienced the highest and the lowest total weight of all the lots among the three sales, as well as auctioned

the most head of cattle versus the other two sales. Descriptive statistics by breed by year are reported in Appendix A.

Table 3.2. NETBIO September Sales at SSLA Totaled for Each Year by Breed

	Sales ($)		
	September 2019	September 2020	September 2021
ANGUS	N/A	N/A	52330.98
BLACK	472059.98	573633.06	550391.79
BRAHMAN	37155.91	25433.87	108660.25
BRANGUS	183577.37	211977.45	157051.68
CHAROLAIS	203820.85	247477.42	148593.43
CROSSBRED	1807943.79	1726925.51	2105268.51
DAIRY	4840.59	N/A	51491.20
EXOTIC	242634.74	285644.85	116711.66
FEEDER	180137.19	321025.92	584678.06
HOLSTEIN	3695.79	3250.19	733.04
LONGHORN	470.40	2127.00	1089.27
JERSEY	N/A	N/A	856.93
MIXED	N/A	N/A	N/A
OKIE	497954.26	602931.64	603520.17
OTHER	1653.75	1953.06	86585.59
RED ANGUS	N/A	18988.62	32528.47
TIGERSTRIPE	3424.10	2684.85	9251.95
TOTAL	3639368.72	4024053.44	4609742.98

Table 3.2 presents the sales data according to each breed from each of the September sales from the respective year. Some of the breeds recorded as N/A, which means that no animals represented that breed for that sale. Brahman, Crossbred, Feeder, Okie, Other, and Red Angus, all show an upward trend between the three sales. While Black, Brangus, Charolais, Exotic Holstein, Longhorn, and Tigerstripe all exhibit a decrease between at least two of the sales. Some of the reasoning for which maybe because of the number of cattle present. Less representation of a breed will drive down the sales totals.

Chapter 4

PRESENTATION OF FINDINGS

The results indicate that cattle prices averaged $792.22/ head prior to the pandemic at the September 2019 auction, while they averaged $805.18/ head six months post the pandemics initiation at the September 2020 auction, and lastly averaged $887.44/head nearly two years after the pandemic existence at the September 2021 auction.[1]

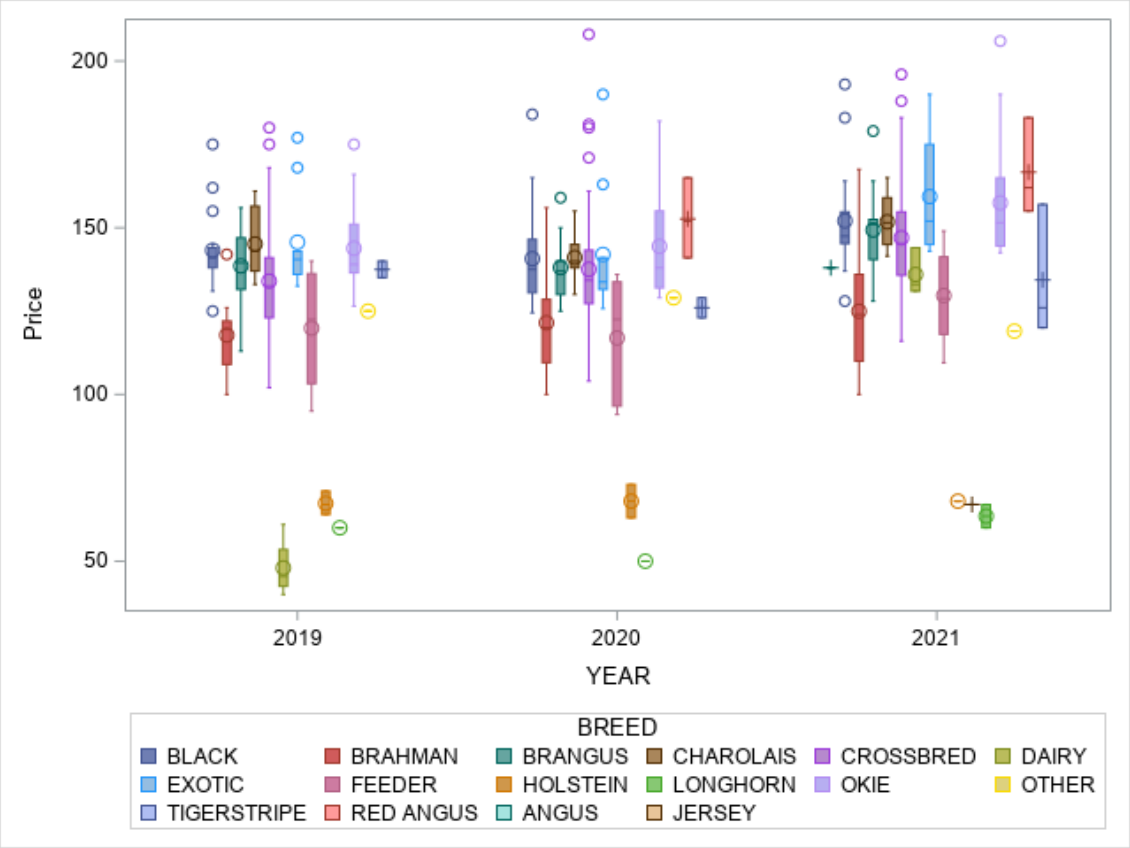

Figure 4.1. Box Plots of Feeder Cattle Prices from the NETBIO September Sale by Breed per Year at SSLA.

Figure 4.1 presents a visualization of the data for the variable price (cwt/$) by breed by year from the NETBIO September sales at SSLA. In general, the most noticeable difference is between the years 2020 and 2021. Dairy breeds including Holstein and Jersey along with

[1] These figures were computed by multiply the average price ($/cwt) of the respective year with the average weight per head.

Longhorn are typically less desirable for this sale and usually do not compete in pricing with the higher fleshier breeds as represented by Figure 4.1. An ANOVA test was conducted using PROC GLM in SAS software 9.4 version. The results are presented in Table 4.2 below.

Table 4.2 SAS Results from ANOVA Test

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	217	2422248.546	11162.436	301.99	<.0001
Error	14723	544209.147	36.963		
Corrected Total	14940	2966457.693			

R-Square	Coeff Var	Root MSE	Price Mean
0.816546	4.380755	6.079737	138.7828

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Sex	1	869.08726	869.08726	23.51	<.0001
Covid	2	14.84926	7.42463	0.20	0.8180
Breed*Sex*Covid	14	8753.65252	625.26089	16.92	<.0001
Avg	1	6769.27091	6769.27091	183.14	<.0001
Avg*Breed	7	13503.49521	1929.07074	52.19	<.0001
Avg*Sex	1	278.45369	278.45369	7.53	0.0061
Avg*Breed*Sex	6	9166.77025	1527.79504	41.33	<.0001
Avg*Breed*Covid	14	2489.47447	177.81960	4.81	<.0001
Avg*Sex*Covid	2	190.87814	95.43907	2.58	0.0757
Avg*Breed*Sex*Covid	7	1924.64114	274.94873	7.44	<.0001
Head	1	895.43588	895.43588	24.23	<.0001
Head*Breed	6	11238.45407	1873.07568	50.67	<.0001
Head*Breed*Sex	7	6131.10547	875.87221	23.70	<.0001
Head*Breed*Covid	14	6496.03441	464.00246	12.55	<.0001
Head*Breed*Sex*Covid	9	9784.85341	1087.20593	29.41	<.0001
Avg*Head	1	1080.02791	1080.02791	29.22	<.0001
Avg*Head*Breed	8	10961.55707	1370.19463	37.07	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Avg*Head*Breed*Sex	6	2753.56805	458.92801	12.42	<.0001
Avg*Head*Breed*Covid	14	3442.58555	245.89897	6.65	<.0001
Avg*Head*Sex*Covid	2	321.87606	160.93803	4.35	0.0129
Avg*Head*Breed*Sex*Covid	8	3637.35443	454.66930	12.30	<.0001

From the ANOVA tables, it can be seen that the variables sex, head, and avg along with interactions of the variables are all statistically significant with a p-value of less than 0.01 percent. The interactions between variables indicate that each combination of variables is said to have a combined effect on price. Although the ANOVA tables indicated that the covid variable was not statistically significant, the Tukey test results in the next table indicate statistical differences among the feeder cattle price means derived from the covid variable. The *F* tests statistic is 301.99 with a p-value less than 0.01, which suggest that the null hypothesis of equality of the means is rejected. That is, there is enough statistical evidence to conclude that at least one of the means from the covid stages (0, 1, and 2) are statistically different from the others. Type III sum squares are preferred in testing effects in unbalanced cases because they test a function of underlying parameters that is independent of the number of observations per treatment combination.

Table 4.3 SAS Results of Tukey Test

Alpha	0.05
Error Degrees of Freedom	14723
Error Mean Square	36.9632
Critical Value of Studentized Range	3.31483

Comparisons significant at the 0.05 level are indicated by ***.				
Covid Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		
2 - 0	8.6448	8.3576	8.9319	***
2 - 1	8.8353	8.5546	9.1159	***
0 - 2	-8.6448	-8.9319	-8.3576	***
0 - 1	0.1905	-0.0996	0.4806	
1 - 2	-8.8353	-9.1159	-8.5546	***
1 - 0	-0.1905	-0.4806	0.0996	

The Tukey test shows the statistical difference between means at a 0.05 confidence level. As indicated by Table 4.3, each of the covid stages (0, 1, and 2) means comparisons were found to be statistically significant, except for the means between stages 0 and 1. This suggests the year 2020 prices are statistically different from 2021 prices, the year 2019 prices are statistically different from 2021 prices, but the prices from the year 2019 were not statistically different from the prices in 2020. The second column of Table 4.3 reports the difference in feeder cattle means among the covid stages. This column indicates practical significance for the means between the covid stages (except between 0 and 1), which also suggest that there is statistical significance among the means (except between 0 and 1). To further examine the data, a multiple regression model was estimated using PROC REG from the SAS software version 9.4. Table 4.4 below reports the results. Based on the results of the multiple regression model, the equation of the sample hyper plane is estimated:

$$\widehat{Price} = 170.87516 - 0.05294\ Avg - 9.58805\ Heifers + 0.700934\ Y20 + 10.28401\ Y21. \quad (4.1)$$

Table 4.4 SAS Results from Multiple Regression Model

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	1244754	311188	2699.60	<.0001
Error	14936	1721704	115.27208		
Corrected Total	14940	2966458			

Root MSE	10.73648	R-Square	0.4196
Dependent Mean	138.78285	Adj R-Sq	0.4195
Coeff Var	7.73617		

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Variance Inflation
Intercept	1	170.87516	0.43278	394.83	<.0001	0
Avg	1	-0.05294	0.00066593	-79.49	<.0001	1.01779
Heifers	1	-9.58805	0.17739	-54.05	<.0001	1.00942
Y20	1	0.70934	0.21877	3.24	0.0012	1.38767
Y21	1	10.28401	0.21732	47.32	<.0001	1.39746

From the results of the multiple regression, it is observed that all of the parameter estimates are statically significant at a 0.01 significance level. The R^2 value of 0.4196 suggest that 41.96% of variation in preconditioned feeder cattle prices is explained by the multiple regression model. The parameter estimate associated with the variable average weight per head (AVG) is statistically significant below the 0.001 level. The parameter estimate suggest that for every pound added to the average weight, price is expected to decrease by 0.05294 ceteris paribus. The parameter estimate associated with the variable Heifers is significant below 0.01 significance level, indicating that heifers were discounted by 9.59/cwt in comparison to steers prices regardless of weight, average, and year, ceteris paribus. This result is consistent with the

literature as steers typically bring a premium over heifers. Statistical significance of the parameter estimates associated with variables *Y20* and *Y21* suggest that preconditioned feeder cattle prices in the year 2020 and 2021 on average are statistically different from the year 2019 which serves as the baseline prior to covid. The Y20 variable suggest that in the September 2020 auction, prices were $7.09/cwt higher on average than at September 2019 auction, regardless of weight, average or, sex, ceteris paribus. Lastly, the Y21 is statistically significant below 0.01, indicating that at the September 2021 auction prices were $10.28/cwt higher on average than the September 2019 auction, regardless of weight, average or, sex, ceteris paribus.

Chapter 5

SUMMARY, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS FOR FUTURE RESEARCH

The covid pandemic has impacted the food industry in many ways. Due to the virus, many industry shutdowns and production line setbacks caused the food industry and meat markets to be affected. Balagtas and Cooper (2021) state that food at home CPI rose 3.5% in the early months of covid and meat alone increased 9%. The meat Industry continued to work efficiently ranking third in exports prior to the pandemic (USDA-FAS, 2021) and still met the demands of consumers as more families were staying home. This meant less eating at restaurants and food service establishments. Additionally, the virus increase the quantity demanded for products on the shelves at grocery stores and food markets. This included all products within the food industry as well as more at home daily used products. Many products experienced shortages or the quantity was limited to consumers. The meat industry is one of the more time sensitive products that is not able to process for consumer availability as quick as other food items. However, auctions and preconditioned sales play a major role in securing meat for consumers.

Preconditioned sales such as NETBIO and the OQBN (Williams, 2021) are value added programs for cattle that strive to enhance beef quality by performing health protocols and starting these cattle on feed to better prepare them for the next phase after auction. They are security measures that feed into many feedlots, which in turn service many packing plants. Any delay or factors that might hinder these sales is a direct down fall to the beef industry. Although these sales are only a few in terms of sales that happen across the nation, every little piece of the puzzle is important to maintain efficiency and prevent gaps in the grocery stores. This study aims

to examine the economic effect of the covid pandemic on cattle prices at a preconditioned sale specifically in the northeast region of Texas referred to as NETBIO.

In summary, a total of 447 lots were observed from the month of September NETBIO auctions during the years of 2019, 2020, and 2021. These years serve as indicators of the covid pandemic direct impact. This study conducted both an ANOVA analysis and multiple regression model. The ANOVA analysis reveal several interaction variables had a combined effect on feeder cattle prices. The most intriguing finding from the ANOVA analysis is the significant difference between the means in prices from the three years of covid. The only years that were not statistically different was between the year 2019 and 2020. The average price per head for the September 2019 auction was $792.22. The September 2020 auction averaged $805.18. Lastly the September 2021 auction averaged $887.44. All averages computed regardless of sex breed, ceteris paribus. The multiple regression model displayed similar results. The parameter estimates of average weight, sex, and covid were said to be statistically significant. The variable sex was assigned a dummy variable to separate steer lots from heifer lots, from which the variable heifer was derived the regression model revealed that heifer and steer prices served to be different. Covid was assigned dummy variables to implicate the level of covid existence, the statistical significance implies that covid did in fact inflate feeder cattle prices. The already perceived conclusions of participants in the beef industry, is confirmed by this study. Ultimately, both the ANOVA analysis and the multiple regression model reveal confirming results of each other, empirically revealing that preconditioned feeder cattle prices from the NETBIO sale were impacted by the covid pandemic.

In conclusion of this study, it was found that prices of preconditioned cattle at the NETBIO sale had increased in the account of covid's impact. This study is beneficial to cattle

producers, specifically to participants of the NETBIO program. Operations that center their production cycle from year to year typically send cattle to market at various times in the year. For those that harvest their cattle in the early fall would have been impacted by the pandemic by collecting a premium for their cattle during this time.

Recommendations for Future Research

This study analyzes preconditioned cattle sales, which consists of mostly just yearling heifers and steers. In most cases sale barns all over the state of Texas host a sale every week for cattle of all ages, such as bulls, cows, breeding heifers, and baby calves, in addition to the yearling steers and heifers. With this being said, future research could investigate the weekly auctions that tend to see more volatility in the market rather than the lesser occurring preconditioned sales like NETBIO. There are also other sales facilities across the state and nation that host their own preconditioned sales, a future researcher might establish a comparison of prices among the differing preconditioned sales to examine their either confirmation or disconfirmation of prices among each other. Furthermore, there are many inputs that are involved in raising cattle from feed cost, veterinary supplies, land leases in some cases, and more all play a big role in a producer's decisions. This would be a reasonable topic to research more specifically during the time of covid when many companies were experiencing shortages of various products.

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APPENDICES

APPENDIX A

Descriptive Statistics by Breed for Each year of September NETBIO Sales during 2019-2021 at SSLA

Table A.1.Descriptive Statistics by Breed for Each year of September NETBIO Sales during 2019-2021 at SSLA

YEAR=2019 BREED=BLACK

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	594	21547.57	8293.24	6097.00	34853.00
AVG(lbs.)	594	562.43	86.16	381.00	755.00
Price($/cwt)	594	142.34	9.00	125.00	175.00

YEAR=2019 BREED=BRAHMAN

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	54	4290.46	1860.65	583.00	7384.00
AVG(lbs.)	54	578.33	140.40	354.00	859.00
Price($/cwt)	54	121.63	11.76	100.00	142.00

YEAR=2019 BREED=BRANGUS

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	220	22704.63	10654.21	1612.00	34846.00
AVG(lbs.)	220	576.80	87.44	446.00	806.00
Price($/cwt)	220	145.55	7.25	113.00	156.00

YEAR=2019 BREED=CHAROLAIS

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	242	25899.40	11834.56	3867.00	42713.00
AVG(lbs.)	242	594.94	82.11	387.00	678.00
Price($/cwt)	242	142.33	7.38	133.00	161.00

YEAR=2019 BREED=CROSSBRED

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	2370	34122.28	13736.00	652.00	59398.00
AVG(lbs.)	2370	576.53	123.39	227.00	933.00
Price($/cwt)	2370	132.93	10.54	102.00	180.00

YEAR=2019 BREED=DAIRY

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	22	3939.50	1608.58	740.00	5077.00
AVG(lbs.)	22	473.41	126.50	289.00	740.00
Price($/cwt)	22	47.50	5.64	40.00	61.00

YEAR=2019 BREED=EXOTIC

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	294	24085.51	9128.40	3554.00	33761.00
AVG(lbs.)	294	590.05	80.13	395.00	669.00
Price($/cwt)	294	140.92	10.84	132.50	177.00

YEAR=2019 BREED=FEEDER

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	182	27041.46	8844.10	1103.00	35190.00
AVG(lbs.)	182	790.64	71.29	718.00	1103.00
Price($/cwt)	182	126.16	12.97	95.00	140.00

YEAR=2019 BREED=HOLSTEIN

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	11	2591.00	1256.69	760.00	3489.00
AVG(lbs.)	11	502.36	82.44	380.00	640.00
Price($/cwt)	11	67.18	2.23	64.00	71.00

YEAR=2019 BREED=LONGHORN

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	2	784.00	0.00	784.00	784.00
AVG(lbs.)	2	392.00	0.00	392.00	392.00
Price($/cwt)	2	60.00	0.00	60.00	60.00

YEAR=2019 BREED=OKIE

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	627	24034.15	10426.29	4380.00	40188.00
AVG(lbs.)	627	570.38	124.78	313.00	762.00
Price($/cwt)	627	140.68	9.42	126.50	175.00

YEAR=2019 BREED=OTHER

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	3	1323.00	0.00	1323.00	1323.00
AVG(lbs.)	3	441.00	0.00	441.00	441.00
Price($/cwt)	3	125.00	0.00	125.00	125.00

YEAR=2019 BREED=TIGERSTRIPE

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	4	1500.25	529.50	706.00	1765.00
AVG(lbs.)	4	617.50	59.00	588.00	706.00
Price($/cwt)	4	138.75	2.50	135.00	140.00

YEAR=2020 BREED=BLACK

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	722	25554.75	10817.03	4660.00	52037.00
AVG(lbs.)	722	580.36	96.23	388.00	745.00
Price($/cwt)	722	138.01	10.93	124.50	184.00

YEAR=2020 BREED=BRAHMAN

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	40	3594.85	1673.19	706.00	6082.00
AVG(lbs.)	40	544.13	93.00	423.00	706.00
Price($/cwt)	40	116.33	15.39	100.00	156.00

YEAR=2020 BREED=BRANGUS

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	256	29654.20	12659.51	1657.00	41039.00
AVG(lbs.)	256	592.95	72.11	450.00	773.00
Price($/cwt)	256	140.29	7.24	125.00	159.00

YEAR=2020 BREED=CHAROLAIS

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	302	30585.77	12658.07	7089.00	45104.00
AVG(lbs.)	302	591.26	81.88	394.00	673.00
Price($/cwt)	302	139.08	6.48	130.00	155.00

YEAR=2020 BREED=CROSSBRED

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	2254	34896.73	15193.91	808.00	56443.00
AVG(lbs.)	2254	576.35	124.19	249.00	916.00
Price($/cwt)	2254	134.15	11.61	104.00	208.00

YEAR=2020 BREED=EXOTIC

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	355	31370.82	12183.96	3848.00	42432.00
AVG(lbs.)	355	601.44	92.69	385.00	742.00
Price($/cwt)	355	134.92	11.81	125.75	190.00

YEAR=2020 BREED=FEEDER

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	307	48734.70	15342.61	3356.00	69597.00
AVG(lbs.)	307	821.63	75.58	724.00	1105.00
Price($/cwt)	307	127.84	9.39	94.00	136.00

YEAR=2020 BREED=HOLSTEIN

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	7	3746.86	1302.09	794.00	4239.00
AVG(lbs.)	7	719.43	32.88	707.00	794.00
Price($/cwt)	7	64.43	3.78	63.00	73.00

YEAR=2020 BREED=LONGHORN

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	9	2416.33	868.00	1259.00	2995.00
AVG(lbs.)	9	472.67	39.50	420.00	499.00
Price($/cwt)	9	50.00	0.00	50.00	50.00

YEAR=2020 BREED=OKIE

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	764	27021.51	9669.13	2852.00	43391.00
AVG(lbs.)	764	569.52	114.97	317.00	761.00
Price($/cwt)	764	140.37	12.55	129.00	182.00

YEAR=2020 BREED=OTHER

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	2	1514.00	0.00	1514.00	1514.00
AVG(lbs.)	2	757.00	0.00	757.00	757.00
Price($/cwt)	2	129.00	0.00	129.00	129.00

YEAR=2020 BREED=RED ANGUS

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	26	4732.08	1540.48	2240.00	6189.00
AVG(lbs.)	26	484.92	29.90	448.00	516.00
Price($/cwt)	26	150.69	8.69	141.00	165.00

YEAR=2020 BREED=TIGERSTRIPE

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	3	1216.67	489.02	652.00	1499.00
AVG(lbs.)	3	717.33	56.58	652.00	750.00
Price($/cwt)	3	125.00	3.46	123.00	129.00

YEAR=2021 BREED=ANGUS

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	51	37921.00	0.00	37921.00	37921.00
AVG(lbs.)	51	744.00	0.00	744.00	744.00
Price($/cwt)	51	138.00	0.00	138.00	138.00

YEAR=2021 BREED=BLACK

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	620	23086.15	11454.58	3142.00	47787.00
AVG(lbs.)	620	593.64	89.51	393.00	785.00
Price($/cwt)	620	150.40	10.09	128.00	193.00

YEAR=2021 BREED=BRAHMAN

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	140	10161.95	5298.79	358.00	18563.00
AVG(lbs.)	140	615.38	95.19	358.00	863.00
Price($/cwt)	140	126.35	14.83	100.00	167.50

YEAR=2021 BREED=BRANGUS

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	172	20167.08	12060.70	2019.00	36196.00
AVG(lbs.)	172	594.83	98.49	454.00	854.00
Price($/cwt)	172	155.04	11.49	128.00	179.00

YEAR=2021 BREED=CHAROLAIS

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	167	18185.14	8949.85	3553.00	30265.00
AVG(lbs.)	167	595.44	83.60	395.00	675.00
Price($/cwt)	167	149.94	6.27	141.50	165.00

YEAR=2021 BREED=CROSSBRED

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	2523	35751.80	16072.07	1303.00	68570.00
AVG(lbs.)	2523	584.68	138.95	231.00	933.00
Price($/cwt)	2523	144.34	12.77	116.00	196.00

YEAR=2021 BREED=DAIRY

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	94	13380.26	2518.74	9221.00	15837.00
AVG(lbs.)	94	402.03	42.27	375.00	485.00
Price($/cwt)	94	136.57	5.67	131.00	144.00

YEAR=2021 BREED=EXOTIC

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	135	14279.55	6458.26	2839.00	22831.00
AVG(lbs.)	135	574.60	88.92	406.00	672.00
Price($/cwt)	135	152.02	12.88	143.00	190.00

YEAR=2021 BREED=FEEDER

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	538	53053.71	29234.60	12750.00	101100.00
AVG(lbs.)	538	835.17	84.13	722.00	1063.00
Price($/cwt)	538	131.08	12.96	109.50	149.00

YEAR=2021 BREED=HOLSTEIN

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	2	1078.00	0.00	1078.00	1078.00
AVG(lbs.)	2	539.00	0.00	539.00	539.00
Price($/cwt)	2	68.00	0.00	68.00	68.00

YEAR=2021 BREED=JERSEY

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	2	1279.00	0.00	1279.00	1279.00
AVG(lbs.)	2	640.00	0.00	640.00	640.00
Price($/cwt)	2	67.00	0.00	67.00	67.00

YEAR=2021 BREED=LONGHORN

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	3	1029.00	509.22	441.00	1323.00
AVG(lbs.)	3	588.33	127.59	441.00	662.00
Price($/cwt)	3	62.33	4.04	60.00	67.00

YEAR=2021 BREED=OKIE

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	703	24999.93	8601.97	1657.00	39275.00
AVG(lbs.)	703	568.58	107.13	322.00	764.00
Price($/cwt)	703	152.21	10.66	142.50	206.00

YEAR=2021 BREED=OTHER

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	73	72761.00	0.00	72761.00	72761.00
AVG(lbs.)	73	997.00	0.00	997.00	997.00
Price($/cwt)	73	119.00	0.00	119.00	119.00

YEAR=2021 BREED=RED ANGUS

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	36	9686.39	3175.19	931.00	12182.00
AVG(lbs.)	36	569.17	47.18	466.00	609.00
Price($/cwt)	36	159.28	6.75	155.00	183.00

YEAR=2021 BREED=TIGERSTRIPE

Variable	N	Mean	Std Dev	Minimum	Maximum
WGT (lbs.)	10	3229.50	1312.29	706.00	4027.00
AVG(lbs.)	10	643.10	116.44	575.00	850.00
Price($/cwt)	10	146.50	16.99	120.00	157.00

APPENDIX B

Extended ANOVA Analysis with All Variable Interactions

Table B.1 Extended ANOVA Analysis of Variable Interactions

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	217	2422248.546	11162.436	301.99	<.0001
Error	14723	544209.147	36.963		
Corrected Total	14940	2966457.693			

R-Square	Coeff Var	Root MSE	Price Mean
0.816546	4.380755	6.079737	138.7828

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	0	0.00000	.	.	.
Sex	1	2601.85418	2601.85418	70.39	<.0001
Breed*Sex	0	0.00000	.	.	.
Covid	1	62.27227	62.27227	1.68	0.1943
Breed*Covid	0	0.00000	.	.	.
Sex*Covid	2	216.61452	108.30726	2.93	0.0534
Breed*Sex*Covid	7	1578.57695	225.51099	6.10	<.0001
Avg	1	6724.53144	6724.53144	181.93	<.0001
Avg*Breed	7	13601.74522	1943.10646	52.57	<.0001
Avg*Sex	1	278.45369	278.45369	7.53	0.0061
Avg*Breed*Sex	6	9166.77025	1527.79504	41.33	<.0001
Avg*Covid	2	431.45667	215.72834	5.84	0.0029
Avg*Breed*Covid	10	1764.75662	176.47566	4.77	<.0001
Avg*Sex*Covid	2	190.87814	95.43907	2.58	0.0757
Avg*Breed*Sex*Covid	7	1924.64114	274.94873	7.44	<.0001
Head	1	844.64380	844.64380	22.85	<.0001
Head*Breed	5	11537.38546	2307.47709	62.43	<.0001
Head*Sex	1	0.85390	0.85390	0.02	0.8792
Head*Breed*Sex	6	1934.61034	322.43506	8.72	<.0001
Head*Covid	2	75.88110	37.94055	1.03	0.3583
Head*Breed*Covid	13	3037.84733	233.68056	6.32	<.0001
Head*Sex*Covid	2	138.86107	69.43054	1.88	0.1529

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Head*Breed*Sex*Covid	7	2773.44396	396.20628	10.72	<.0001
Avg*Head	1	1093.75616	1093.75616	29.59	<.0001
Avg*Head*Breed	8	10961.55707	1370.19463	37.07	<.0001
Avg*Head*Sex	1	101.53983	101.53983	2.75	0.0975
Avg*Head*Breed*Sex	6	2753.56805	458.92801	12.42	<.0001
Avg*Head*Covid	2	29.40068	14.70034	0.40	0.6719
Avg*Head*Breed*Covid	14	3442.58556	245.89897	6.65	<.0001
Avg*Head*Sex*Covid	2	321.87606	160.93803	4.35	0.0129
Avg*Head*Breed*Sex*Covid	8	3637.35443	454.66930	12.30	<.0001

VITA

Kelley Smith attended Texas A&M University-Commerce where she received her Bachelor of Science in Agribusiness, with a double minor in finance and interdisciplinary studies in the fall of 2020. Afterwards she became a graduate assistant for the college of agriculture sciences and natural resources, conducting research in farm financial benchmarking as well as making progress towards a master's degree in agriculture sciences. Concluding the 2021 year with a graduate certificate in Agribusiness, she was also working at local agribusinesses to gain industry experience. In addition, she attended numerous conferences and meetings all over the state of Texas gaining knowledge about research and professionally networking with other institutions and organizations.

Kelley's current research involves examining factors that influence the prices of the cattle market. She is a passionate agriculturalist that is devoted to helping and making an impact in the business side of the agricultural industry. In her spare time, she volunteers at youth agriculture events that help future generations see their potential and develop skills.

2200 Campbell St. Commerce, TX. 75428
Ksmith106@leomail.tamuc.edu