Impact of Cash Settlement and Market Fundamentals on Feeder Cattle Basis

by

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Abstract

With volatile cattle markets, comes substantial amounts of price risk for all parties involved in the industry. Hedging with futures markets to mitigate risk is a common practice performed by commercial producers. For this to be an effective risk management tool, the futures contract must function correctly by accurately representing the price and quality of the underlying product. Often times, commodity futures contracts are settled by physical delivery. However, two livestock contracts transitioned to a cash settled index, feeder cattle in 1986 and lean hogs in 1997, to enhance the performance of the contract and promote participation by commercial users. Eliminating high delivery costs, reducing any issues with the grading process when the product is delivered, and portraying a truer commercial value, are some of the benefits of a cash settlement index.

There has been some speculation that dates back to the 1980's regarding whether the live cattle futures contract should switch to cash settlement rather than physical delivery. This study was done to measure the impact the change to cash settlement had on the hedging ability of the feeder cattle futures contract. Even though the feeder cattle contract represents a different sector of the industry, the results still provide some insight as to whether cash settlement can be advantageous for a futures contract.

The ability to forecast basis is critical when hedging with futures to manage risk. The magnitude of basis prediction error (BPE), or the difference between expected basis and actual basis, is a common method used to measure the hedging ability of a futures contract. This procedure was utilized to analyze the effects the change to cash settlement had on BPE in six different regions: Kansas, Missouri, Nebraska, North/South Dakota, Oklahoma, and Texas. Expected basis was calculated using a two, three, and four year historical average technique for each respective week to contract expiration. Other market factors were also included in the models to ensure the cash settlement adjustment was not the sole reason for BPE variations over time. To estimate the impact the different elements have on basis predictability, Ordinary Least Squares regression was used for each of the three stacked models.

For the two-year historical basis prediction error model, Kansas was the only area with a statistically significant value indicating cash settlement reduced BPE by $0.18. Three states,

Kansas (-$0.24/cwt.), Missouri (-$0.17/cwt.), and Texas (-$0.16/cwt.), showed a statistically significant decrease in BPE due to cash settlement for the three-year historical basis prediction error model. Also, the coefficient for Oklahoma was just slightly above the statistically significant level. However, the four-year model had moderately different results. The estimate for Kansas was statistically significant at -$0.18/cwt. meaning cash settlement reduced BPE, while the Dakotas region actually showed a statistically significant increase in BPE by $0.18/cwt. This research provides evidence that cash settlement can improve the basis predictability of a futures contract depending on the region and technique used to calculate expected basis.

Table of Contents

List of Figures

List of Tables

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Chapter 1 – Introduction

With most large investments of capital, comes a significant amount of risk, and this is no different in the cattle industry. Several different strategies can be implemented for individuals in the beef industry to mitigate risk which has become more critical in the recent years as extreme price volatility is more prevalent. The most common method to limit risk is by way of a basic hedge in the futures market, or to take a position in the futures market to capture margin from a potential price move that goes against the current commercial position. This equates to essentially locking in a price for the product. To ensure this is an effective strategy, the futures contract must accurately represent the underlying commodity with correct specifications and settlement procedures.

Traditionally, futures contracts are settled by physical delivery where the actual product changes hands when two parties have open positions at the time of contract expiration. This is successful if the product is primarily homogenous and can be delivered at multiple locations. However, if there are varying grades of the commodity, the futures price will converge to the lowest par delivery grade. One potential solution to eliminate that issue, while also removing high delivery costs, is with the implementation of cash settlement based on an index rather than physical delivery. Though, it is vital the index constitutes the average price of all grades of the commercial product. This can be accomplished and limit manipulation at the same time with a large geographical sample, incorporating commercial prices from all types of the product, using prices from an extended time period, or some combination of the methods.

The Chicago Mercantile Exchange (CME) replaced physical delivery with mandatory cash settlement for the feeder cattle futures contract in September 1986. CME also replaced the physically delivered live hog contract with the mandatory cash settled lean hog contract in February 1997. According to CME in 1985, the reason for the feeder cattle contract adjustment was to:

“1) eliminate the uncertainties and disputes associated with the grading of CME feeder deliveries; 2) eliminate the risk of a long receiving delivery at an inconvenient delivery location and/or receiving an undesirable type of feeder; 3) eliminate the costs incurred in making or taking delivery on the contract; 4) eliminate the need for periodic contract amendments regarding discounts for non-par grades, weights, and locations…; and 5) reduce the basis variability for users of the contract" (Rich and Leuthold, 1993). Bottom line, CME made the adjustment in hopes of increasing participation from commercial users by making the basis more predictable and ultimately ensuring convergence occurs between the futures and cash prices.

Discussion involving the idea of modifying the current live cattle futures contract from physical delivery to cash settlement has surfaced in the recent years. According to a media article in 2016, CME was considering some changes to the live cattle contract, and cash settlement was on the list (Polansek, 2016). This was brought about due to many complaints from traders about the volatility. However, the National Cattlemen's Beef Association (NCBA) opposed the idea of cash settlement for the live cattle contract (Tri-State Livestock News, 2016). Although, this was not always the case for NCBA as the NCBA board agreed to submit a report in 1997 to CME to potentially develop a cash settled index for cattle futures (Schreiber, 1997). It is evident this conversation has gone on for decades, since there was academic research completed on this subject in the 1980's.

Even though the feeder cattle contract represents a different sector of the industry relative to the live cattle contract, this current study was done to analyze the effect cash settlement has had on the hedging ability of the feeder cattle contract to provide some insight as to whether cash settlement can potentially improve a futures contract. The ability to accurately predict basis is a major piece of risk management when using futures contracts. Basis prediction error, or the difference between expected and actual basis, is a common method used to quantitatively measure the hedging effectiveness of a futures contract. This research also evaluates the impact fundamental and behavioral economic factors have on basis predictability in the feeder cattle market while attempting to capture the seasonality of basis error. These explanatory variables were incorporated into the models to ensure the influence on basis prediction error was not strictly due to the cash settlement revision. The markets analyzed in the stacked models cover a six-region area (Kansas, Missouri, Nebraska, North/South Dakota, Oklahoma, and Texas) to examine if there is any geographical differences in the effects of cash settlement. To estimate the impact the different elements have on basis predictability, Ordinary Least Squares regression was used.

1.1 Organization of Thesis

This thesis is broken down into eight chapters. Chapter 2 includes the history and changes for the CME feeder cattle contract, and an empirical visual of the current index. Chapter 3 reviews historical research involving issues and benefits of cash settlement, as well as studies that analyzed cash settlement implications for the live cattle, feeder cattle, and lean hog contract. Chapter 4 displays the conceptual framework for this study. The empirical models used are described in the Chapter 5. Chapter 6 explains where the data came from and how it was configured, while also providing the descriptive statistics. The results and discussion regarding the findings are found in Chapter 7. Finally, Chapter 8 is the limitations and conclusions of the study.

Chapter 2 - Feeder Cattle Futures Contract History

To keep up with industry standards and trends, the Chicago Mercantile Exchange (CME) has made several adjustments to the feeder cattle futures contract throughout history. The changes have been made to enable the contract to be better utilized as a reliable and efficient risk management tool for commercial users. The par load weight ranges, contract size, the number of market locations included in the index calculation, and the organization who reports the prices for the index, are examples of the changes.

2.1 Contract Specifications

The feeder cattle futures were first listed on November 30, 1971, beginning with the March 1972 contract (CME, 2017-2018). Contract months March through May and August through November were traded (CME, 2017-2018). The contracts first started off as a physically delivered contract with the par delivery points being Omaha, NE; Oklahoma City, OK; and Sioux City, IA; while multiple other locations were available, but discounts were applied (Commodity Futures Trading Commission, 1987). An additional contract month, January, was added several years later, and was first traded in 1978 (CME, 2017-2018). Those eight contract months have remained the same since. Options were also made available as another form of risk management starting with the January 1987 contract (CME, 2017-2018).

As the average weight of cattle increased over time, so has the contract specifications. When the futures were first introduced in 1971, the size of the contract was 42,000 pounds (CME, 2017-2018). The size has changed twice since then. In 1981, starting with the January 1982 contract, the size grew to 44,000 pounds (CME, 2017-2018). Since November 1992, with the change first being made to the January 1993 contract, the size has been 50,000 pounds (CME, 2017-2018). The par load weight ranges can be found in Table 6.1.

To account for the increasing volatility of the feeder cattle futures throughout history, CME has revised the price limit moves multiple times. The price limit started off as \$1.00/cwt. before quickly being changed to \$1.50/cwt. for the November 1974 contract (CME, 2017-2018). Beginning with the November 2003 contract, the price limit became expandable to \$3.00/cwt.

and \$5.00/cwt. (CME, 2017-2018). Shortly after, beginning with the March 2004 contract, the \$1.50/cwt. limit was replaced with \$3.00/cwt. limit move at all times (CME, 2017-2018). Since the January 2015 contract, the price limit has been amended to \$4.50/cwt. and expandable to \$6.75/cwt. (CME, 2017-2018).

2.2 Cash Settlement Index

The most significant alter to the feeder cattle contract was the change to cash settlement from physical delivery with the September 1986 contract that was first listed in January 1986. When the contract first transitioned to cash settlement, CattleFax collected and calculated the index price known as the U.S. feeder steer price (USFSP). According to CME, the USFSP was a weighted average price from four different regions of the country that was made up of 27 different states (Schroeder and Mintert, 1988). It was weighted based on the number of feeder cattle as of January 1st for each year in the different regions (Schroeder and Mintert, 1988). The index was a moving average of the last seven calendar days and consisted of both auction and direct sales of feeder cattle (Kenyon et al., 1991). Since the January 1993 contract, USDA-Agricultural Marketing Service (AMS) prices have been utilized to formulate the index price (CME, 2017-2018). At that time the geographic spectrum of the index was reduced to the current 12-state region that consists of: Colorado, Iowa, Kansas, Missouri, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, and Wyoming.

According to the CME Rulebook (2018), for final settlement, “All contracts open as of the termination of trading shall be cash settled based upon the CME Feeder Cattle Index™ for the seven calendar days ending on the day on which trading terminates.” The index, as of May 2018, consists of transactions from the following weight/frame score categories: 700 to 899 pound Medium and Large Frame #1 feeder steers, and 700 to 899 pound Medium and Large Frame #1-2 feeder steers (CME Rulebook, 2018). All feeder cattle auction, direct trade, video sale, and internet sale transactions in the 12-state region are included (CME Rulebook, 2018). However, certain types of feeder cattle reported as fancy; thin; fleshy; gaunt; full; having predominantly dairy, exotic, or Brahma breeding; are excluded from the calculation (CME Rulebook, 2018). If the feeder cattle are sold through direct trade, video sale, or internet sale;

they must be quoted on an FOB basis, 3% shrink or equivalent, with pickup within 14 days (CME Rulebook, 2018).

The calculation of the index is a weighted average of the transactions previously discussed and a seven calendar day moving average. From each USDA-AMS report in the 12-state region, CME multiplies the number of head by the corresponding weighted average weight to have total pounds in each relevant weight/frame score category (CME Rulebook, 2018). To get the total dollars sold in the respective weight/frame score category of the report, the number of head is multiplied by the correlating weighted average weight (CME Rulebook, 2018). Then that product is multiplied by the corresponding weighted average price (CME Rulebook, 2018). Once these two calculations are completed, the total pounds in each category are aggregated to formulate the total pounds for that report, and the total dollars sold in relevant categories are aggregated to get the total dollars (CME Rulebook, 2018). Then, for any relevant transactions from the USDA-AMS reports that happened in the past seven calendar days; the total pounds and total dollars are aggregated within the 12-state region (CME Rulebook, 2018). To obtain the final CME Feeder Cattle Index™ value, the total dollars sold in the 12-state region during the seven calendar day period is divided by the total pounds sold for the same region and time period (CME Rulebook, 2018). An empirical model of the index would be the following

(1) $$\sum_{i=1}^{n} \sum_{c=700\ lb.}^{899\ lb.} head_{i,c} \times weight_{i,c} = totallbs$$

(2) $$\sum_{i=1}^{n} \sum_{c=700\ lb.}^{899\ lb.} head_{i,c} \times\ weight_{i,c} \times price_{i,c} = totaldol$$

(3) $$\frac{\left(\sum_{d-6}^{d} totaldol\right)}{\left(\sum_{d-6}^{d} totallbs\right)} = \text{CME Feeder Cattle Index™}$$

where c denotes all the cattle sold for the different relevant categories for the i number of reports in the 12-state region and d is the current time in calendar days. Description of the variables can be found in Table 2.1.

Table 2.1 - Description of Variables for the CME Feeder Cattle Contract Empirical Formula

Variable	Description
$head$	Number of head sold in each report for the relevant weight/frame score categories
$weight$	Weighted average weight in each report for the relevant weight/frame score categories
$price$	Weighted average price in each report for the relevat weight/frame score categories
$totallbs$	Total pounds sold from the the reports in the 12-state region for the relevant weight/frame score categories
$totaldol$	Total dollars sold from the reports in the 12-state region for the relevant weigh/fram score categories
i	Denotes all the reports from the 12-state region
c	Denotes the cattle sold in the relavant categories (700-899 lb. Medium and Large Frame #1 and #1-2 steers)
d	Denotes time in calendar days

Chapter 3 - Literature Review

Since there has only been two commodity futures contracts switch from physical delivery to cash settlement, there is not a significant amount of variation in the types of studies testing the effects of cash settlement on basis. The first studies done on feeder cattle in the 1980’s had to use some major assumptions. As time progressed and more data became available, multiple methods have been utilized to measure the implications.

The live hog contract made its transition from physical delivery to a cash settled lean hog contract in February 1997. Even with the large amount of vertical coordination in the hog industry, which differs from the cattle industry structure, and the fact the contract represents a different sector of the industry when compared to the feeder cattle contract; the research still provides some critical insight. The results from both the lean hog and feeder cattle studies will be utilized to compare the findings of the current research.

First, there will be a discussion over a few studies describing an instance when cash settlement failed to perform in the futures market; some of the benefits and disadvantages of cash settlement; how to properly formulate an index; and why it may not have been possible for the live cattle futures contract to be cash settled in the 1980’s.

3.1 A Case when Cash Settlement Failed due to Potential Issues with Cash Settlement

There are very few things that work out perfectly throughout time, so Cornell (1997) analyzed some of the potential problems of a cash settlement index using the municipal bond futures market that was settled on the Bond Buyer Index (BBI). The BBI was constructed of 40 municipal bonds that met five criteria points. The BBI was revised twice a month to ensure the current bonds met the strict criteria. When a cash settled index is used, the main goal is for the index to accurately represent the underlying product being traded in the open market. Cornell (1997) provided some reasons why this does not always occur.

To try to eliminate manipulation, at least six different municipal bond buyers not involved in the cash or futures markets were contacted twice a day to get price quotes. Because of this method of price discovery, there was a chance the quotes would be stale or not up to date. Although the brokers contacted did not participate in the market, traders with a significant position in the futures market could still manipulate the cash price. Cornell (1997) tested the accuracy of the index by analyzing a time when the interest rates moved rapidly on the day the nearby contract expired to see how this contract reacted compared to the deferred contracts and cash securities. This occurred in the afternoon of December 19, 1995 when the Federal Reserve cut the target federal funds rate from 5.75% to 5.5%.

Cornell (1997) looked at the December municipal bond contract (expiring contract), March municipal bond contract, and March Treasury bond contract. For the days leading up to December 19th, the contracts were highly correlated in the direction and magnitude of their moves. This, however, was not the case after the critical announcement made by the Federal Reserve as the December contract did not move while the others adjusted approximately one point.

Cornell (1997) concluded the reason for the failed movement and poor representation by the futures contract and BBI settlement price was due to illiquid traded securities, stale price quotes, or manipulation done by futures traders. Cornell (1997) suggested when a cash settlement index is utilized, tests should be done to ensure the index size, prices used, and data collection methods are the optimal representation of the underlying security, especially when the securities are illiquid.

3.2 Index Considerations for Cash Settlement

Garbade and Silber (1983) conducted an economic analysis on some of the factors that go into developing the ideal index for cash settlement. The study described some of the main issues with physical delivery and why cash settlement would be a better alternative. One of the most logical and significant problems with physical delivery is when high delivery costs do not allow convergence of the cash and futures prices as the expiration approaches. Garbade and Silber stated, “The second problem with physical delivery is that precautionary demands by shorts preparing to deliver the commodity can push up local cash market price of deliverable grades.” This squeeze generates a higher than appropriate cash price at the delivery point. The opposite could happen as well for longs anticipating delivery where the cash price is lower than it should be.

To offset the problems with physical delivery, mandatory cash settlement could be a better alternative. According to Garbade and Silber (1983) there are two primary benefits to mandatory cash settlement. Since there is not physical delivery, squeezes and dumping are eliminated and the local cash price should accurately represent the true commercial value of the commodity. Plus, riskless transactions in the futures markets causes the futures market to move to the value of the index. As long as the index accurately represents the true commercial value of the commodity, the futures should converge to the proper commercial value. But, Garbade and Silber (1983) concluded, "Cash settlement is not desirable if the cash settlement index is inaccurate and if delivery costs are low and price distortions due to squeezes and dumping are unlikely."

Obviously, how the index is constructed is critical to how well the cash settled index represents the underlying commodity. Garbade and Silber (1983) suggested the source of price data comes from transaction prices rather than bid and offer quotations or price indications. This is ideal if the frequency of trading is high and if the terms of the trade are reasonably homogenous [Garbade and Silber (1983)]. The study also recommended price data be aggregated together to eliminate any errors having a significant effect on the index. This could be a simple or weighted average of prices over a long or short period of time. It all depends on the commodity's commercial price volatility and ease of data collection. Garbade and Silber (1983) proposed if the commercial value is stable the timeframe could include several days with an almost equal weight for each observation. For volatile prices, short time periods, several hours for instance, and unequal weight may be the best option.

Garbade and Silber (1983) concluded cash settlement can enhance closer convergence of the cash and futures price, can eliminate high costs for physical delivery, new types of futures contracts can be used when physical delivery is not possible, and futures contract designs become more versatile. However, the most important aspect of a cash settled index is that it correctly displays the true commercial value of the commodity.

3.3 Past Issues with Cash Settlement for Live Cattle Futures

Kahl, Hudson, and Ward (1989) conducted a study to figure out if the live cattle futures contract could be cash settled similar to the feeder cattle contract in the 1980's. It provided insight on the potential problems associated with a cash settled index and why it may not work for every contract or sector of an industry. The reason behind this research was brought about due to the many complaints from market participants during that time. The four main concerns included: grading inaccuracies at some delivery locations, the contract acted as a dumping ground for lower quality cattle, delivery points outside of the highly concentrated feeding region adversely effected futures prices and caused uncertainty, and the contract specifications did not allow certain breeds and had a maximum load weight of 40,000 pounds (Kahl et al., 1989).

Since there was no data for cash settled futures prices, a simulation of basis behavior was done similar to previous studies for the feeder cattle contract. Price quotes from several different regions reported by Cattle-Fax and the USDA were used from January 1980 through December 1986 to construct different variations of an index. The USDA boxed beef cutout value was also used and multiplied by 0.6204 to create a live price equivalency. The basis for physical delivery was calculated at each location as the difference between the cash price and the futures price on the day of contract expiration, and also the difference between the cash price and average of the futures prices on the final ten trading days for each expiring contract. The cash settled basis was calculated as the cash price at each location minus the price index on the day of maturity.

Kahl et al. (1989) concluded there was one index, made up of six states (Iowa, Nebraska, Kansas, Colorado, Oklahoma, and Texas), that was statistically significant at the 0.05 level and showed a decrease in variance for cash settled basis compared to the physically delivered basis. The other six indices showed different results where most of them increased variance.

Kahl et al. (1989) described some of the differences between the feeder cattle and live cattle contracts and why they could not be compared side by side regarding cash settlement. When the potential for manipulation was discussed for the live cattle contract, the authors were concerned with the high concentration of beef-packing companies being able to influence the fed cattle price. Since there was a lower concentration of feedlots, it would've been more difficult to influence the feeder cattle price. The geographic concentration of the cattle feeding industry was expected to generate some issues as well. More than half of the U.S. cattle were fed in three states which would have made it easier to manipulate the price. The feeder cattle cash settled index, at the time, was made up of 27 different states making it more difficult to influence the price.

At the time of this study the Livestock Mandatory Reporting (LMR) was not implemented by the USDA for livestock markets, so Kahl et al. (1989) was concerned with how this process was going to work for the live cattle. The Cattle-Fax index, which was the best alternative, was primarily made up of price quotes from Cattle-Fax members who were sellers. Very few, if any, buyers reported the transaction prices. However, this may not be a significant issue now because of the strict LMR regulations as long as current prices for immediate delivery are used in the index.

Bottom line, Kahl et al. (1989) suggested if a cash settled futures contract was used the price quotes be averaged over several days and several states or regions. This idea was recommended to help limit manipulation, but if one firm is a large buyer in several states this may not solve the issue (Kahl et al., 1989). Another positive for cash settlement that was presented was the ability for the live cattle futures and live cattle options to expire simultaneously. Kahl et al. (1989) never made a final decision as to whether cash settlement would be a better solution as opposed to physical delivery for the live cattle futures contract. It was concluded that the tradeoffs of the potential positives and negatives be analyzed closely before a decision is made (Kahl et al., 1989).

3.4 Historical Studies Analyzing the Effects of Cash Settlement for the Feeder Cattle Contract

While the transition to cash settlement for the feeder cattle contract was pending, Cohen and Gorham (1985) tested some of the potential implications the change could have. The study compared the proposed feeder cattle cash settled contract against the current physical delivery contract that was in place at the time. Cohen and Gorham (1985) used weekly cash prices during 1980-1984 from the USDA to measure the maturity basis mean and variability against the CME physical delivery contract and the Cattle-Fax U.S. feeder steer price (USFSP) which represented the cash settled contract. After measuring the basis at fourteen different market locations from 1980-1983, the mean basis for cash settled increased, on average, by $4.19/cwt. to about +$1.46/cwt. When the states are broken down into specific regions, the mean basis for cash settled increased $4.01/cwt., on average, from 1980-1984 compared to physical delivery. Cohen and Gorham (1985) also looked at the seasonal changes of the mean maturity basis by measuring basis for each contract month during 1980-1984 for four of the largest individual markets. The results show the most significant increase in basis, for cash settlement relative to physical delivery, was for the August, October, November, and January contracts, while the smallest change was in March, April, May, and September.

To measure basis variability, Cohen and Gorham (1985) used the standard deviation of basis during the last week of trading for each respective contract. When the 38 cash markets (individual markets and state averages) were analyzed, the results indicate maturity basis variability was reduced at every location for cash settled compared to the physical delivery contract. The smallest standard deviation decrease was $0.20/cwt. at Dodge City, KS, while the largest reduction was $1.27/cwt. for Florida. Colorado and Oklahoma tied for the smallest maturity basis variance at $0.56/cwt. for cash settlement. Two locations, Omaha, NE and West Fargo, ND, had the highest standard deviation for maturity basis at $2.21/cwt. when calculated for cash settlement. These results suggested, the contract performance would be improved under cash settlement. One would have anticipated there to be stronger basis and reduced basis variability at maturity. Since the Cattle-Fax USFSP index was used as a proxy for the cash settlement futures, the results must be interpreted with this taken into consideration.

The division of Economic Analysis for the Commodity Futures Trading Commission (CFTC) conducted two studies in the late 1980's on the feeder cattle futures contract to analyze cash settlement effects. The research used 600-800 pound steer prices from Oklahoma City to calculate basis. The Commodity Futures Trading Commission (1987) report shows the results of the second study that included basis relative to the spot contract for the contract months of January, March, April, and May for the year 1986 (physical delivery) and 1987 (cash settlement). There was a dramatic change in basis with an average change of +$3.26 for the cash settled contracts compared to the physical delivery contracts. The more critical thing to inspect was how basis volatility changed between the two periods. CFTC's two studies compared the average basis for the first seven contract months under cash settlement (September 1986-May 1987) and the same corresponding contract months a year earlier under physical delivery (September 1985-May 1986). Under cash settlement the average basis had a range of $1.29 or +$2.85 to +4.14. Under physical delivery the Oklahoma City average basis had a range of $5.47 or -$2.46 to +$3.02.

The takeaway from the studies is, based on a simple average for basis at Oklahoma City, the volatility had decreased which was beneficial to hedgers. However, this was done with a limited number of observations and did not take into account other factors that could affect the basis changes. Plus, this was only done at one location, even though it was one of the largest feeder cattle markets at the time, there could be substantial price differences between market locations due to the type of cattle and current market demands for that particular area (Commodity Futures Trading Commission, 1987).

One of the first published academic studies analyzing the effects the transition from physical delivery to cash settlement had on hedging risk was by Elam (1988). The research started off with estimating the ideal hedge ratio before and after cash settlement. Elam (1988) used feeder cattle prices from Arkansas auction markets from 1977 to April 1986 on a weekly basis. At the time, Arkansas prices were highly correlated with other markets, and it was assumed this was an accurate representation for all markets. The research was conducted on medium framed, number 1 steers and heifers. The study included several weight ranges (300-400, 400-500, 500-600, and 600-700 pounds) of both sexes to show if there were any differences between each group. Averages of daily CME futures prices for a specified week were used as the physical delivery futures. Since there were no cash settlement futures at the time, the reported Cattle-Fax USFSP for 600-800 pound steers was the proxy for cash settlement futures which needs to be taken into special consideration when analyzing the results.

Elam (1988) reported the change in hedging risk, based on a three-month hedge and the standard deviation of the difference of the net and anticipated prices, depended on sex; weight range; and contract month. For instance, it was expected the hedging risk to be lower with cash settlement for 600-700 pound steers and heifers in all contract months, except January for steers. As the weight decreases there was more variation in the results. For steers weighing less than 600 pounds, there was an increase in hedging risk with cash settlement ranging from 21.5% to 36.9% for the March, April, and May contracts, with the exception of March for 500-600 pound steers. Heifers weighing less than 600 pounds followed the same pattern with a range of .5% to 24.6% increase. Plus, heifers weighing 400-500 pounds saw a slight increase of 1.3% in hedging risk for the August contract with cash settlement. All other results for feeder cattle below 600 pounds showed a decrease in hedging risk with cash settlement.

Shortly after, and similar to Elam's (1988) study, Schroeder and Mintert (1988) evaluated the impact cash settlement would have on hedging risk for four different market locations. Ideal hedge ratios were also estimated at the beginning of the study. Amarillo, Dodge City, and Kansas City were three of the markets analyzed in the study and included in the weighted price of the Cattle-Fax USFSP. The fourth location, not included in the USFSP data, was the Illinois Direct. Weekly prices were used for the following weight ranges: 300-400, 400-500, 500-600, 600-700, and 700-800 pounds. From January 1977 to August, 15th 1986, weekly average closing CME futures quotes were used as the physical delivery prices. Just like Elam (1988), the Cattle-Fax USFSP weekly average price was used as a proxy for cash settled futures prices and needs to be taken into special consideration when evaluating the results.

Schroeder and Mintert (1988) reported findings very similar to Elam's (1988). Based on a three-month hedge and using the standard error of the net price received minus the expected price to calculate hedging risk, the hedging risk with cash settlement decreased for the majority of the weight ranges and contract months, with 50% of those being significantly different than zero at the 0.05 level (Schroeder and Mintert, 1988). Feeder cattle over 600 pounds showed a considerable decrease in hedging risk with cash settlement. The exception to this was Dodge City with the September contract for heifers ranging from 600-700 and 700-800 pounds, where there was a significant increase in hedging risk with cash settlement compared to physical delivery. Schroeder and Mintert's (1988) results did contrast with Elam's (1988) in regards to the lighter weight cattle and the spring months results. Schroeder and Mintert (1988) found there to be zero instances when there was a statistically significant increase in hedging risk for cash settlement during the spring time frame. This was likely due to market location differences. Elam, and Schroeder and Mintert agreed that cash settlement would be beneficial for producers by reducing hedging risk.

Kenyon et al. (1991) was next to study how cash settlement effected the basis variability and basis forecast error. Since the feeder cattle contract had been cash settled for several years, actual futures prices were used which differs from the previous research. The study conducted by Kenyon et al. (1991) used 600-700 and 700-800 pound, medium frame, number one muscle score steers assuming a hedge ratio of one to test weekly basis variance. The results from weekly prices collected from markets in Virginia and Oklahoma showed all basis variance decreased, however three of the four categories did not have a statistically significant difference in basis variation at the 0.05 level from physical delivery to cash settlement. Steers weighing 700-800 pounds from Virginia did have a statistically significant different variance at the 0.05 level based on an F-test.

For hedgers, the more critical risk management tool is being able to predict basis at the time the cattle are marketed, so the findings of the second piece of the work are more substantial to a producer. Kenyon et al. utilized prior research to develop basis estimation models for individual steer and heifer lots sold in Virginia markets that took into account basis with respect to the nearby contract, weight, frame size, breed, lot size, sale size, sex, and specified the futures contract months and the timing of the year. Using the results from these models, Kenyon et al. forecasted the termination basis for 600-800 pound, muscle score one cattle from 1983 to 1988. The assumptions for these models were producers have to predict the actual weight, frame size, and muscle score at the time cattle are marketed. Basis forecast error was calculated as the difference between the expected basis and the actual basis. The standard deviation of the basis forecast error was used to analyze if basis prediction had improved for cash settlement compared to physical delivery. The results show the standard deviation of basis forecast error increased during cash settlement for two groups of cattle, spring steers (12%) and fall heifers (30%). However, an F-test indicated the fall heifers were the only group with a statistically significant different standard deviation at the 0.05 level. For fall steers and spring heifers, the standard deviation of basis forecast error decreased by 3% and 7%, respectively, but neither were statistically significant at the 0.05 level. The results showing cash settlement did not significantly decrease basis forecast error in Virginia differ from Elam's, and Schroeder and Mintert's work. This could have been due to the varying market locations, different weight ranges, the fact that Virginia prices were not included in the USFSP calculation, or the other two studies used the USFSP as a proxy for cash settled future prices.

As more data became available for the cash settlement timeframe, Rich and Leuthold (1993) analyzed the effects the changes had on the feeder cattle contract performance by looking at 600-700 pound steers and heifers from 27 market terminals in 20 different states for three and half years before and after cash settlement. Using weekly cash and futures price averages for the week of contract expiration, the hypothesis of a decrease in variance of basis at expiration was tested to compare pre and post cash settlement. Another test investigated whether the mean basis level during the expiration week was greater during the cash settled time period. These two hypotheses were also tested using daily steer prices from three markets: Amarillo, TX; Oklahoma City, OK; and Dodge City, KS (Rich and Leuthold, 1993). The weekly results from an F-test indicated basis risk, measured by the standard deviation at the time of expiration, decreased during cash settlement for 71% of the contemporaries. But, only 8 were significant at the 0.05 level and 13 at the 0.10 level with the majority of them being heifer datasets. Of the 15 out of 52 comparisons that increased in basis variability; only one, located in California, was significant at the 0.05 level. The average mean hypothesis test showed basis levels increased and were statistically significant, according to a T-test.

The daily results were similar to the weekly that were just discussed. One difference is Oklahoma City's basis variance did decrease at the 0.05 significance level during cash settlement. "Although this is a limited comparison, the change in Oklahoma City result does suggest that average prices across time and including 'clean-up' prices can slightly distort actual hedging conditions" [Rich and Leuthold (1993, p. 507)].

When modified Levene statistics were used to test the weekly basis variability, only six of the comparisons indicated a decrease in basis variance at the 0.05 significance level. A Mann-Whitney test was also ran on the basis variances. The results are similar to what was previously discussed. Plus, the eight locations not used to calculate the USFSP had a lower basis standard deviation for delivery week during cash settlement.

Rich and Leuthold (1993) also ran ordinary least squares regression using the delivery week basis standard deviation as the dependent variable after logarithmic transformation. The independent variables included sex, cash settlement as a dummy variable, and location for 23 market terminals as a binary variable. The coefficient of the cash settlement was negative and statistically significant at the 0.05 level meaning cash settlement had reduced basis variability for the expiration week. Rich and Leuthold estimated hedging risk had decreased by 7.25% for the industry which was small when considering the basis levels.

Bottom line, Rich and Leuthold concluded cash settlement had caused hedging risk to decrease for the whole feeder cattle market, but can vary between individual market locations. Some other findings in the study indicated that basis risk at contract expiration had seen a decline at specific markets and the basis mean had moved closer to zero. Rich and Leuthold stated as a result of these findings, cash settlement had improved the feeder cattle contract for some users of the futures contract.

Schmitz (1997) did some further work to test how both feeder cattle and live cattle contract specification changes affect basis. The focus will be on the feeder cattle contract. There were two major changes that happened in the 1980's and 1990's. The first occurred in September 1986 when the contract transitioned to cash settlement, and the other was in January 1993 when the total weight specifications for each contract increased from 44,000 to 50,000 pounds and a new settlement index was created. This study analyzed four different periods. The first two (August 1981 to August 1986 and August 1986 to August 1991) were used to compare the effects of cash settlement. The last two periods were used to analyze the effects of the other contract specifications and will not be discussed as the priority of this current research is on cash settlement.

Schmitz obtained the daily closing futures price, cash price, and basis data from Tick Data Inc. of Denver, CO. When looking at the basis variance difference between the first and second period, there was a statistically significant increase at the 0.10 level for the standard deviation of basis after cash settlement. It was a slight increase of 2.34 to 2.77. The futures daily close price and cash price showed a statistically significant increase in standard deviation of 3.85 to 7.92 and 3.30 to 9.76, respectively. Schmitz stated that because there was an increase in both futures and cash price variance, it was hard to declare that cash settlement was the sole reason for the basis variance change.

Using the same data, Schmitz also analyzed the changes on an intra-delivery view, meaning each respective contract was compared in the two different time periods on a period by period basis (i.e. January 1982 vs January 1987). In this method, six times the basis variance statistically decreased and five times variance increased after cash settlement was implemented. This study did not provide a definitive answer as to whether or not cash settlement improved the hedging risk of the feeder cattle contract. There are too many factors not accounted for that could have had an effect on the futures, cash, and basis variance.

Lien and Tse (2002) used a bivariate Generalized Autoregressive Conditional Heteroscedasticity model to analyze the effects of cash settlement on feeder cattle basis and hedging ability. The data included all the futures contracts from September 1977 through December 1998. Weekly data was used, and nearby futures were utilized until about three weeks before contract expiration when they were rolled to the next contract. When comparing the two different periods, the basis average and variance decreased during cash settlement compared to physical delivery. There was a substantial change of 16.027 to 4.392 in the variance, which plays a role in basis predictability, meaning this was supportive to hedgers.

Lien and Tse (2002) utilized a minimum-variance hedge ratio to analyze the hedging changes. A one-period hedge horizon was used. During cash settlement, the average hedge ratio was reduced from 0.383 to 0.295, and the sample variance of the ratio decreased from 0.0080 to 0.0038 (Lien and Tse 2002). “In terms of futures hedging, cash settlement led to smaller and more stable hedge ratios” [Lien and Tse (2002, p. 9)]. The variance of the hedge portfolio also saw a reduction in variance of 4.698 to 1.542 after the transition to cash settlement. As a result of these findings, Lien and Tse concluded the switch to cash settlement helped the performance of the feeder cattle futures market and should be favorable for hedgers.

Chan and Lien (2002) utilized multivariate stochastic volatility models which allows for time-varying volatility to test convergence and basis variability of the feeder cattle contract before and after cash settlement was introduced. Cash prices for 600-700 pound feeder cattle from Oklahoma City and the nearby futures price were used from September 1977 to December 1998. Once the nearby futures reached about three weeks before maturity, it was rolled over to the next upcoming contract. When analyzing the summary statistics, the unconditional mean basis decreased after the change to cash settlement from 0.536 to 0.509. Chan and Lien (2002) anticipated this result since physical delivery futures go to the cheapest deliverable grade, while cash settlement is a weighted average. The basis volatility or standard deviation also decreased from 3.999 to 2.094.

Before the stochastic volatility models were ran, Chan and Lien (2002) had to prewhiten the time series to derive white noise. Using the optimal lag for the model, the results for physical delivery showed the constant was not statistically significant but the coefficient for lagged basis was significant. According to Chan and Lien, this means lagged basis was a strong predictor of current basis. For cash settlement, both coefficients were significant at the 0.05 level. The results show the constant increased while the slope coefficient decreased relative to physical delivery meaning lagged basis had a smaller impact on predicting current basis during cash settlement (Chan and Lien 2002).

The estimates from the stochastic volatility model indicate basis became less volatile during cash settlement. Plus, the volatility became less common, according to Chan and Lien. Bottom line, the transition to cash settlement resulted in the basis becoming more stable which is beneficial for hedgers, and the contract performance, as a whole, improved compared to the physical delivery timeframe.

One of the most recent studies to incorporate the impact cash settlement had on basis forecasting was done by Tonsor et al. (2004). Though this was not the main goal of the research, it still provides some useful insight. Using Dodge City, Kansas, feeder cattle prices and daily nearby futures price with the corresponding sale day, the basis was predicted using a historical average technique. The absolute basis forecast error, the difference between predicted and actual basis, was the dependent variable for a regression model. The model was ran using ordinary least squares estimates, but then a bootstrapping technique was used to account for autocorrelation and heteroscedasticity. A binary variable was used as an independent variable to represent the time periods when the feeder cattle contract was physically delivered (denoted by 0) and cash settled (denoted by 1). Since the coefficient estimate was positive and statistically significant at the 0.05 level, it means predicting basis became more difficult during the cash settlement timeframe. The study also included an independent variable that represented the calendar year of the forecast. Because this coefficient estimate was negative and statistically significant at the 0.05 level, meaning basis became easier to forecast over time, it counteracted some of the cash settled binary variable results. The finding regarding an increase in basis prediction error, but not by a substantial amount, was different than what several studies discovered. It is important to keep in mind Tonsor et al. (2004) only used one location.

3.5 Historical Studies Analyzing the Effects of Cash Settlement for the Lean Hog Contract

One of the first studies to measure what could potentially happen to hedging effectiveness in the hog industry if the futures contract was cash settled was done by Kimle and Hayenga (1994). Since the contract did not transition to cash settlement until February 1997, Kimle and Hayenga simulated ten different potential indices to estimate basis variability. The research was done on 19 USDA reported states or markets from January 1985 to September 1990. Three simple moving averages (1-, 3-, and 5-day) were tested for each index.

Kimle and Hayenga (1994) compared the basis standard deviation on the day of expiration for four indices, assumed to be some of the most correct alternatives, against the current futures contract. The indices included some combination of Iowa/Minnesota, Indiana, Illinois, Ohio, and North Carolina prices. Standard deviation of basis for the indices ranged from \$0.60/cwt. to \$0.64/cwt., while the current contract standard deviation was \$1.29/cwt. Bottom line, the cash settlement indices had better convergence when compared to the current futures contract. Basis variability for the indices was one half of the physical delivery contract. These results would imply that with the correct index, a cash settled futures contract would provide a more effective hedging tool and be a better representative of the cash prices. It is critical to keep in mind this was a simulated indices test of basis variability.

A study performed by Ditsch and Leuthold (1996) was done comparing the live and lean hog futures contracts to analyze which contract would be the best hedging tool for producers. The research was done before the first lean hog contract had become the nearby contract, but the same index formula was used as a proxy for cash settlement from May 1994 to December 1995. The Omaha cash hog price was used to represent the cash price. Two different methods, minimum-variance hedging ratios and the Myers-Thompson framework, were used to measure hedging effectiveness and basis variance for both contracts to minimize final prediction error. Also, several models were utilized using different lagged variables and hedge lengths.

When analyzing the results from the minimum-variance regressions, the lean hog index was significantly better than the live hog in all of the regressions, according to Ditsch and Leuthold. The lean hog index exceeded the hedging effectiveness with respect to the live hog futures, especially in the short term. The Myers-Thompson results were very similar to those just discussed. The hedging effectiveness estimates were much more supportive for the lean hog index compared to the live hog futures, especially in the short-term according to Ditsch and Leuthold.

In summary, hog producers should have been pleased that Ditsch and Luethold (1996) anticipated the cash settled lean hog futures to be a much more effective contract to hedge with than the live hog futures contract that was being utilized at the time.

Once more data became available, Frank et al. (2008) analyzed basis behavior, variability of basis close to contract expiration, and *ex-ante* basis risk or the ability to forecast basis, during cash settlement compared to physical delivery from October 1985 to April 2008. To measure the basis behavior, a simple average for basis was calculated during 20 trading days prior to expiration, and the basis value was observed on the first Wednesday of the expiration month for each respective contract. Standard deviation was calculated similarly using the 20 trading days prior to expiration. Cash prices came from the Iowa/Minnesota region. The February, April, June, July, August, October, and December contracts were used in the tests. When all the months were averaged together, the results show basis level became more negative during cash settlement for the first Wednesday of the expiring contract. The average basis level, when all contracts were included, went from -$1.42/cwt. during physical delivery to -$2.62/cwt. during cash settlement and was statistically significant at the 0.05 level for both a Fligner-Policello test and a t-test. The four contracts, February, July, August, and October, experienced a substantial change from one period to the other. Too further test the basis level, a regression model was used with the independent variables being a dummy variable to denote each time period and dummy variables to represent the contract months. The basis level was the dependent variable. The estimates show basis became more negative by about -$1.15/cwt. during cash settlement and was very different for each contract month. These result estimates would indicate convergence performed better at the beginning of the expiration month during physical delivery relative to cash settled contracts.

When analyzing the findings of the average basis for the last 20 trading days prior to expiration, Frank et al. (2008) discovered the results are similar. Once the contract months are compiled all together, the average basis level grew after the change to cash settlement from -$1.40/cwt. during physical delivery to -$2.40/cwt. and was statistically significant for both the Fligner-Policello test and t-test at the 0.05 level. The regression model shows the same thing. The average basis level for the last 20 days increased or became more negative by -$0.99/cwt for cash settlement. For both tests, each contract month's results can fluctuate considerably.

A chart showing the standard deviation of basis for the last 20 days before expiration displayed a large standard deviation for the June, October, and December 2004 contracts. Frank et al. suspected this was from the substantial growth in U.S. pork exports since beef exports were basically zero due to BSE. When statistically analyzing the standard deviation change from the two different periods, the average standard deviation of basis, including all contracts, increased during cash settlement from $1.37/cwt. to $1.81/cwt. The change was significant at the 0.05 level for both the Fligner-Policello and t-test. April, June, and December were the contracts with the largest change, but keep in mind the BSE incidence that occurred in 2004

(Frank et al., 2008). A regression was ran with similar variables to the previous models, but with the standard deviations as the dependent variable. Another model was used with the addition of a dummy variable for the April, June, and December 2004 contracts. Both regression estimates indicated an increase of basis standard deviation at expiration after the transition to cash settlement. Without making adjustments for the 2004 contracts the standard deviation increased by $0.43/cwt., and increased by $0.35/cwt. with the incorporation of the respective 2004 contract dummy variable. Frank et al. stated that even after running several models, each with unique modifications, basis variability before expiration increased during the cash settlement period.

For the basis forecasting section of the study, Frank et al. (2008) predicted basis on a one-, three-, and five-month horizon. An OLS regression model was used with the dependent variable being the change in basis, from the time basis is first measured (one-, three-, five-month horizon), and what the actual basis was on the first Wednesday of the expiration month. The estimated variance of the regressions were used to analyze *ex-ante* basis risk by doing an F-test (Frank et al., 2008). When all of the different contract months for each of the horizons were combined, the standard deviations of the errors were not statistically different for cash settlement compared to physical delivery. Bottom line, the results of the F-tests show *ex-ante* basis risk was not effected after the transition to cash settlement, according to Frank et al. When a regression was ran using Newey-West standard errors to account for autocorrelation, the estimates indicated basis prediction did not improve or get worse after the contract settlement change (Frank et al.)

In conclusion, this study suggested the basis level and variability increased during cash settlement compared to physical delivery. However, results show hedgers who regularly predict basis at expiration with a legitimate process, would not expect a significant change in forecast error.

Chapter 4 - Conceptual Framework

This research is being done to retest some of the results from studies conducted more than 10 years ago. Obviously, more data is available now and the way feeder cattle are marketed has changed over the years. Video auctions are gaining popularity. Since the 1980's, some of the same auction markets no longer exist or new ones have come to the scene. Also, as the size of feedlots, the primary buyers of feeder cattle, continue to grow over time, one would assume the buying power of the firms may increase. This study is conducted to provide insight on whether cash settlement of the feeder cattle contract still allows the contract to be a better hedging tool in the modern market structure compared to when it was physically delivered. A lot of the concepts and empirical work in this research is similar to that done by Coffey, Tonsor, and Schroeder (2018) which analyzed factors affecting hedging in the live cattle market. The concepts used are different compared to the majority of the prior work done on this topic. Some compared the standard deviation of the basis between the two periods, others analyzed the standard deviation of the basis prediction error, and most studies did not take into account other market fundamentals that could have been impactful on basis. This research attempts to combine ideas from prior studies about this topic and the concepts used by Coffey et al. (2018).

In a volatile market structure, such as the feeder cattle markets, hedging can be utilized as a risk management tool to limit price risk. An effective hedge is when the cash and futures prices move together and the basis, at the time the hedge is lifted, is at the expected level (Purcell and Koontz, 1999). Basis is defined as the difference between the cash price and the futures price. Coffey et al. (2018, p. 20) described, "A perfect hedge is one where actual net price received equals expected cash price." However, forecasting the exact expected price is nearly impossible, especially as length of the hedge increases. This is due to hedging error which can be explained as the difference between expected and actual cash prices relative to futures (Coffey et al., 2018). Hedging error occurs because the basis that was predicted at the time the hedge was placed, is different than when the hedge is lifted (Coffey et al., 2018). Basis prediction error (BPE) can be described as the difference between expected basis and actual basis (Coffey et al., 2018).

There are many factors that can play a role in expected basis being incorrect. Besides the variations between the size, quality, etc. of individual feeder cattle lots causing the basis to be different than expected, basic market fundamentals can also effect BPE. This would include, but not limited to, the supply and demand of feeder cattle in the region the cattle are being sold. During an expansion phase in certain regions, more heifers would be kept as replacements resulting in a tighter total supply of feeder cattle. The opposite could be said during a contraction stage of the cattle cycle. It is common in the cattle industry to use historical information of basis levels to predict future basis. But to no surprise, prices and market fundamentals of one year are not always the same the following year. Tonsor et al. (2004) discovered basis forecasting is improved when current basis information is added to the basis prediction calculation. This supports the idea that both historical and current market fundamentals can affect basis levels. BPE can be defined as a function of how current factors, that affect basis, have changed compared to past history (Δx) and other variables representing current and unique market conditions for that particular week (z) (Coffey et al., 2018). The other variables (z) could be a vast array of short-term factors such as critical government policy news, natural disasters, etc. that are specific for that week and year (Coffey et al., 2018). BPE can be defined as

(4) $$basiserror = f(\Delta x, z)$$

for the live cattle market, according to Coffey et al. (2018), but is also the same for the feeder cattle market.

As mentioned before, the main focus of this research is the impact cash settlement has had on hedging. Other variables are included in the model to measure the changes in the market that have taken place over time to ensure the sole reason for a potential change in basis prediction error is not just because of the transition to cash settlement.

Chapter 5 - Empirical Model

From the BPE formula used in the conceptual model, Coffey et al. (2018) estimated BPE as

$$basiserror = f(\Delta x, z, \varepsilon) \quad (5)$$

where ε is a random error and the other variables remain the same.

There are many methods used to predict basis and that plays a major role in the value of BPE (Coffey et al., 2018). Jiang (1997) discovered in grain markets, using an average of basis for the prior three years is a very common practice. According to Dhuyvetter and Kastens (1998), using historical averages of basis as a forecasting tool is practical, while the optimal number of years is commodity specific. With this in mind, a simple historical average method is used in this study. Tonsor et al. (2004) discovered, when strictly using historical averages, a three year average is the optimal number of years to use to most accurately predict feeder cattle basis. Basis can also be predicted using a corresponding calendar week or week to contract expiration technique. Tonsor et al. (2004) found no statistical difference between the two methods. Based on these findings, the main discussion for this study will come from forecasting basis using the prior three year average for the particular week to contract expiration. A two year and four year historical average to predict basis will also be used in this study to further test the results of how cash settlement impacted hedging effectiveness. BPE is measured in nominal price terms, and gives the absolute value in \$/cwt. BPE, using a three year historical average, was calculated using the following formula

$$basiserror_t = \left| Basis_t - \left(\frac{\sum_{y-3}^{y-1} Basis_t}{3} \right) \right|, \quad (6)$$

where $basiserror_t$ is the basis prediction error for week to expiration t for the nearby futures contract, and $Basis_t$ is the actual basis, or difference between the cash price and futures price, in a particular week to contract expiration. The term in parentheses represents expected basis since it is the average basis for the past three years, where y is the current year. Obviously, the term in parentheses would be slightly different to calculate the average basis for the past two and four years. It is critical to remember the value of $basiserror$ does not mean the basis is weaker or stronger than historical averages. It is simply the distance between actual and expected basis. An actual basis that is $2/cwt. weaker than the expected basis for a particular week would still give you the same $basiserror$ value if the actual basis was $2/cwt. stronger than expected.

To measure the effect the transition from physical delivery to cash settlement had on basis predictability; a dummy variable $(settlement)$ was included in the model with 0 representing physical delivery and 1 being cash settled for the futures contract. The main goal for switching to cash settlement was to enhance the performance of the contract and attract more participants, in particular commercial hedgers, to trade the contract. With this in mind, it is expected the estimate will have a negative relationship with $basiserror$, meaning the timeframe when cash settlement was in place hedgers should be able to more effectively predict basis.

As an estimate for (Δx), a formula essentially identical to $basiserror$ was used that includes live cattle futures and corn prices. Trapp and Eilrich (1991) concluded that live cattle futures prices and corn prices impact feeder cattle basis in the Oklahoma City market. A ratio of the deferred live cattle futures price and cash corn price was used to measure the change in those current prices with respect to a three year historical average. (Δx) can be calculated by

(7) $$\Delta x_t = \left| x_t - \left(\frac{\sum_{y-3}^{y-1} x_t}{3} \right) \right|.$$

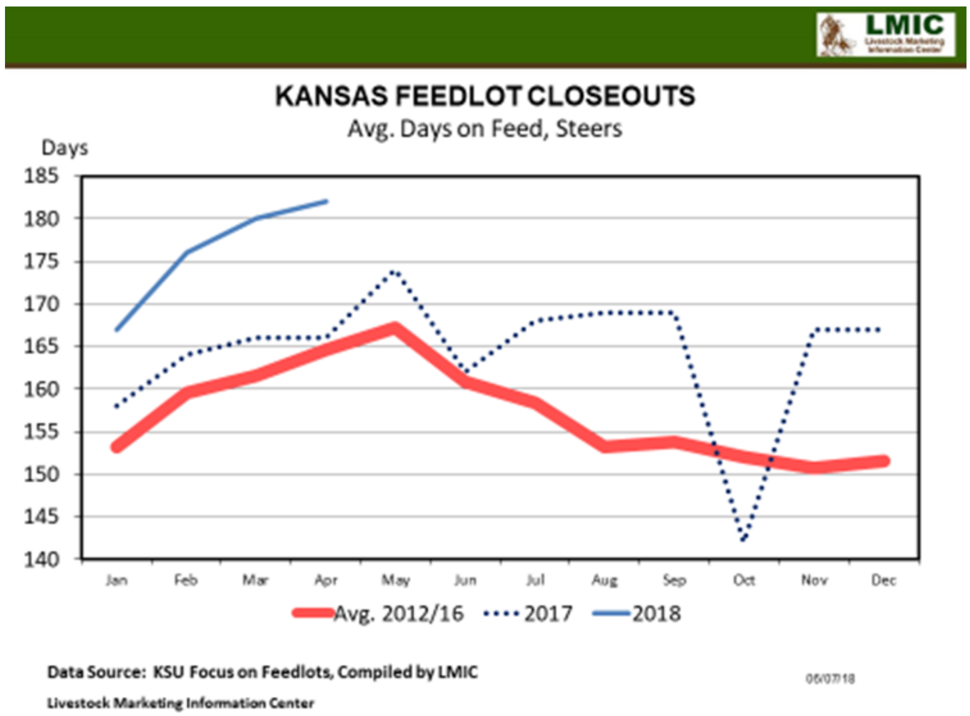
The formula for the two and four year historical averages would be identical, but with different number of years.

The deferred live cattle futures price ($/cwt.) and the spot Omaha cash corn price ($/bu.) ratio, or (x), would be defined as

(8) $$x_t = lccratioerr = \frac{Live\ Cattle\ Futures\ Price_t}{Omaha\ Cash\ Corn\ Price_t}.$$

Deferred live cattle futures prices were used to represent a potential price the feedlots who purchased the feeder cattle would be able to sell the fed cattle in the future. This is critical because depending on the deferred futures price and the potential breakeven price for the feeder cattle, it gives the cattle feeder an idea as to whether it is a smart business decision to procure feeder cattle at the time. The deferred live cattle futures may also allow the feedlots to hedge a potential profit for the purchased feeder cattle. In today's industry, it is typical for cattle to be on feed for at least five months. Data provided by Livestock Marketing Information Center shown in Figure 5.1 shows the average days on feed for steers in Kansas feedlots.

Figure 5.1 - Average Days on Feed for Steers in Kansas Feedlots



This was the idea used to line up the correct deferred live cattle futures contract at the time the feeder cattle are being marketed. Table 5.1 shows the corresponding feeder cattle market week and the live cattle futures contract price that was used, where t is time in weeks to expiration for the nearby feeder cattle futures contract and y is the contract year.

Table 5.1 - Deferred Live Cattle Quotes used in Ratio

Feeder Cattle Market Month	**Live Cattle Futures Contract**
$\text{January}_{t,y}$	$\text{June}_{t,y}$
$\text{February}_{t,y}$	$\text{August}_{t,y}$
$\text{March}_{t,y}$	$\text{August}_{t,y}$
$\text{April}_{t,y}$	$\text{October}_{t,y}$
$\text{May}_{t,y}$	$\text{October}_{t,y}$
$\text{June}_{t,y}$	$\text{December}_{t,y}$
$\text{July}_{t,y}$	$\text{December}_{t,y}$
$\text{August}_{t,y}$	$\text{February}_{t,y+1}$
$\text{September}_{t,y}$	$\text{February}_{t,y+1}$
$\text{October}_{t,y}$	$\text{April}_{t,y+1}$
$\text{November}_{t,y}$	$\text{April}_{t,y+1}$
$\text{December}_{t,y}$	$\text{June}_{t,y+1}$

For example, feeder cattle sold the first week of April could be expected to be harvested around the September timeframe. Since this is the case, the October live cattle futures price may be thought as the best price estimator the fed cattle will receive during that time. Also, theoretically the October live cattle contract would be the futures contract feedlots would use to hedge the purchased feeder cattle. For this example, the price of the October live cattle futures price for the first week of April in year y would be used in the calculation of the $lccratioerr$ ratio.

Since feed costs add up to be one of the most significant input costs, besides the feeder cattle purchase price, when feeding cattle; the spot Omaha cash corn price was used as a proxy for feed costs. The corn price acts as the input part of the output:input price ratio.

The ratio is calculated as a ratio error, in absolute value terms, compared to the previous three year average. Therefore, a larger $lccratioerr$ value would mean the market conditions, either output prices or input costs, have changed relative to prior years. Since these two measurements are significant factors in the fed cattle industry, it is expected this will certainly be impactful to $basiserror$. It is anticipated $lccratioerr$ will have a positive relationship with $basiserror$, or when $lccratioerr$ strays further from the historical average so will $basiserror$.

There are two variables, pl and $transportation$, that represent some of the current factors effecting the feeder cattle markets. These would be represented by (z) in the $basiserror$ function. Both are measured contemporaneously and not with respect to historical averages. The variable pl is actually used to measure the behavioral economics that impact feeder cattle prices and basis. The explanatory variable, pl, is an estimate of the average profits or losses the cattle feeder has experienced in the past four weeks, and how this translates to the willingness of feedlots to purchase feeder cattle above or below the futures price. If the cattle feeding industry has been profitable, this could cause an optimistic long-term outlook, even if the deferred live cattle futures say otherwise. This may result in feeder cattle prices being higher than one would anticipate, and potentially leading to breakeven prices being higher than deferred live cattle futures, not allowing the cattle feeder to hedge a profit. If this scenario plays out, it is expected pl would have a positive impact on $basiserror$. However, the opposite could happen as well when feedlots have had negative margins and not willing to pay high or even average prices for feeder cattle. Both of those scenarios do not always occur, but a positive impact on $basiserror$ is expected for both sequence of events. Based on this analysis, and how difficult it is to accurately measure the potential behavior, or psychological aspect of the feedlot industry, it is hard to determine the directional impact pl will have on $basiserror$.

The cattle feeding industry is heavily concentrated in the Great Plains (Colorado, Iowa, Kansas, Nebraska, Oklahoma, and Texas), while the feeder cattle market is spread over a broader range of the country. Even though this study was performed with feeder cattle prices from states in the central plains, transportation costs are still critical to analyze. The no. 2 diesel fuel index (not seasonally adjusted) from the producer price index reported by the Bureau of Labor Statistics (2017), was used as a proxy for delivery costs. In theory, as the price of fuel increases, delivery costs should increase as well. As a result, the ability to predict basis relative to historical averages will be more difficult. This indicates $transportation$, the variable representing delivery costs, will have a positive relationship with $basiserror$.

Binary variables were also included to denote each calendar month and capture the seasonality of basis prediction error. Considering there are only eight feeder cattle contracts for a calendar year, there are times during the year when the nearby contract will not expire for two or three more months. It is expected the further from contract maturity the more difficult to predict basis. If the cash and futures prices converge, like they are supposed to, as the contract approaches maturity; there will be a smaller range for basis to fluctuate resulting in a more predictable basis. Based on this, it is anticipated the off contract months, February, June, July, and December, will have a positive relationship with $basiserror$. June should have the largest positive impact, since the nearby contract does not expire until the last Thursday in August, and the futures price should actually represent prices at the time of maturity. It is difficult to determine the directional impact the other months may have on $basiserror$. January was considered the default month in the model.

Observations from six different regions were stacked in the model, so binary variables were used to indicate each individual region. In the original model Kansas (ks) was the default. The other five regions were North/South Dakota (dk), Missouri (mo), Nebraska (neb), Oklahoma ($okla$), and Texas (tex). North and South Dakota were combined to ensure there was a consistent and large enough volume of feeder cattle sold year round that would give an accurate representation of the cash price. A significant coefficient would mean it is easier or more difficult to forecast basis in a particular region compared to Kansas. Even though all six of these regions are included in the CME feeder cattle index, there could still be some variation in basis prediction error between areas due to local supply and demand factors that are unique for an individual region. Interaction terms between the settlement dummy variable and the region binary variables were also included to measure the effect cash settlement had on each of the six regions observed in the model.

Based on a three year historical average to predict basis and calculate the live cattle futures to cash corn ratio error, the final empirical model is specified as

$$basiserror_t = \beta_0 + \beta_1 settlement_t + \beta_2 lccratioerr_t + \beta_3 pl_t + \beta_4 transportation_t + \beta_5 feb_t + \beta_6 mar_t + \beta_7 apr_t + \beta_8 may_t + \beta_9 june_t + \beta_{10} july_t + \beta_{11} aug_t + \beta_{12} sept_t + \beta_{13} oct_t + \beta_{14} nov_t + \beta_{15} dec_t + \beta_{16} okla_t + \beta_{17} tex_t + \beta_{18} neb_t + \beta_{19} mo_t + \beta_{20} dk_t + \beta_{21} okcs_t + \beta_{22} txcs_t + \beta_{23} necs_t + \beta_{24} mocs_t + \beta_{25} dkcs_t + \varepsilon_t$$

where, t represents time in weeks to expiration for the nearby feeder cattle futures contract. The description of each variable for the models can be found in Table 5.2.

Table 5.2 - Desription of Variables in the Empirical Model

Variable	Description
$settlement$	Denoted as 1 when the feeder cattle contract was cash settled, 0 otherwise
$basiserror$	Absolute value of basis prediction error based on three year historical average basis
$twoyrbasiserr$	Absolute value of basis prediction error based on two year historical average basis
$fouryrbasiserr$	Absolute value of basis prediction error based on four year historical average basis
$lccratioerr$	Absolute value of deferred live cattle futures to spot corn price ratio prediction error based on three year historical average ratio
$twoyrlcc$	Absolute value of deferred live cattle futures to spot corn price ratio prediction error based on two year historical average ratio
$fouryrlcc$	Absolute value of deffered live cattle futures to spot corn price ratio prediction error based on four year historical average ratio
pl	Four week, rolling average of estimated feedlot profits and losses on a per head basis
$transportation$	Producer price index for No. 2 diesel fuel (seasonally unadjusted) on a monthly basis
Calendar Month Binary Variables (Base= January)	
feb	Denoted as 1 if the week to contract expiration is in February, 0 otherwise
mar	Denoted as 1 if the week to contract expiration is in March, 0 otherwise
apr	Denoted as 1 if the week to contract expiration is in April, 0 otherwise
may	Denoted as 1 if the week to contract expiration is in May, 0 otherwise
$june$	Denoted as 1 if the week to contract expiration is in June, 0 otherwise
$july$	Denoted as 1 if the week to contract expiration is in July, 0 otherwise
aug	Denoted as 1 if the week to contract expiration is in August, 0 otherwise
$sept$	Denoted as 1 if the week to contract expiration is in September, 0 otherwise
oct	Denoted as 1 if the week to contract expiration is in October, 0 otherwise
nov	Denoted as 1 if the week to contract expiration is in November, 0 otherwise
dec	Denoted as 1 if the week to contract expiration is in December, 0 otherwise
Region Binary Variables (Base= Kansas)	
$okla$	Denoted as 1 if the feeder cattle cash price originated from Oklahoma, 0 otherwise
tex	Denoted as 1 if the feeder cattle cash price originated from Texas, 0 otherwise
neb	Denoted as 1 if the feeder cattle cash price originated from Nebraska, 0 otherwise
mo	Denoted as 1 if the feeder cattle cash price originated from Missouri, 0 otherwise
dk	Denoted as 1 if the feeder cattle cash price originated from North/South Dakota, 0 otherwise
Interaction Terms	
$okcs$	Denoted as 1 if the feeder cattle cash price orginated from Oklahoma during the cash settlement period, 0 otherwise
$txcs$	Denoted as 1 if the feeder cattle cash price orginated from Texas during the cash settlement period, 0 otherwise
$necs$	Denoted as 1 if the feeder cattle cash price orginated from Nebraska during the cash settlement period, 0 otherwise
$mocs$	Denoted as 1 if the feeder cattle cash price orginated from Missouri during the cash settlement period, 0 otherwise
$dkcs$	Denoted as 1 if the feeder cattle cash price orginated from North/South Dakota during the cash settlement period, 0 otherwise

It is critical to keep in mind the β coefficients in the model do not indicate whether the basis will be stronger or weaker, rather the coefficients display if there will be an increase or decrease in basis prediction error ($basiserror_t$). A negative coefficient or reduction in basis error is more favorable for hedgers. A positive estimate for a β coefficient would mean an increase in that particular variable results in a larger difference in current basis compared to the predicted basis. The opposite would be true for a negative estimate for a β coefficient.

Chapter 6 – Data and Descriptive Statistics

The feeder cattle cash prices used to calculate basis came from CattleFax. As previously mentioned, CattleFax was the organization that collected and reported the feeder cattle prices in the early stages of the feeder cattle contract. When the contract first transitioned to cash settlement, the index was calculated by CattleFax. After the Livestock Mandatory Price Reporting (LMR) from the USDA Agricultural Marketing Service (AMS) was implemented, CattleFax formulated its feeder cattle prices primarily based off the LMR prices. The CattleFax prices are based on medium and large frame, muscle score number one cattle and attempted load lots (CattleFax, 2018). Prices are reported as a weighted average and aggregated together on a state or region basis in hundred pound increments.

The feeder cattle price data consists of weekly steer prices from the first week of February 1976 to the last week of October 2016, while excluding December 1976 and January 1977 prices. Those data points were left out because the January futures contract was not listed until 1978. This was done to ensure the expected basis calculation was consistent for those particular months during the late 1970's.

The specifications for the feeder cattle contract have gone through several changes throughout history, especially the weight ranges for a par load. This study was done assuming a one to one hedge ratio using steer prices that were in line with the feeder cattle futures contract specifications. Table 6.1 displays the changes made to the futures contract and the formula for the weighted cash price that was used for the respective time period (CME, 2017-2018).

Table 6.1 - Weighted Average Feeder Cattle Cash Price Formula (CME, 2017-2018)

Time Period	Feeder Cattle Futures Contract Par Weight Range	Weighted Average Cash Price Formula (i.e. 750 lb. price= averge price of 700 to 799 lb.)
Prior to September 1986	500 to 800 lbs. (650 lbs. as the average with discounts and premiums for above or below 650 lbs.)	1 x 650 lb. price
September 1986 to November 1992	600 to 800 lbs.	0.5 x 650 lb. price + 0.5 x 750 lb. price
December 1992 to November 1999	700 to 799 lbs.	1 x 750 lb. price
December 1999 to May 2005	700 to 849 lbs.	0.67 x 750 lb. price + 0.33 x 850 lb. price
June 2005 to October 2016	650 to 849 lbs.	0.25 x 650 lb. price + 0.5 x 750 lb. price + 0.25 x 850 lb. price

To calculate the other part of the basis equation, daily CME Feeder Cattle futures prices were obtained from Commodity Research Bureau (CRB). Weekly average futures prices of the nearby contract were calculated using the daily close quotes for the corresponding week. The weeks were then categorized into respective months. Futures had to be traded during at least three days under the same month of a particular week in order for that week to be used and to decipher which month the week would be classified as. For instance, a week ending Friday July 2nd would actually fall under the June category, since there were three days in June (June 28th-30th) for that week. The futures data was then arranged by week to expiration for each corresponding nearby contract. When the contract was physically delivered, the contract expired on the 20th calendar day (CME, 2017-2018). During cash settlement, the contract expires on the last Thursday of the contract month with some exceptions to the November contract and when a holiday falls on the last Thursday or on any of the four days prior to the last Thursday (CME Rulebook, 2018).

The weekly, weighted CattleFax feeder cattle cash price and the CME feeder cattle futures quote were used to calculate basis for each week observed. Expected basis was then calculated using a simple average of the prior three year basis for the corresponding week to expiration. Because of the first three years being used to calculate expected basis; $basiserror_t$ observations for January did not begin until 1981, December started in 1980, and the other calendar months began in 1979. The two year and four year historical averages were also used to calculate expected basis. To keep observations consistent; $twoyrbasiserr_t$, calculated using the two year average, began the same time as $basiserror_t$. Since an additional year was needed to calculate expected basis for $fouryrbasiserr_t$, the observations start a year after those used for $basiserror_t$. Some of years were left out during the late 1980's when the contract was transitioning to cash settlement. This was done to ensure the historical basis averages did not include basis from both physical delivery and cash settlement time periods. The dependent variables for each model, $basiserror_t$, $twoyrbasiserr_t$, and $fouryrbasiserr_t$, were calculated using equation (6). Equation (6) would be slightly different for the two and four year historical average method. Each variable simply measures the hedging errors market participants would have experienced if basis was forecasted using the different methods.

The independent variable $lccratioerr$, which represents the live cattle futures to cash corn ratio error, is calculated using two different price data series. The daily CME Live Cattle Futures quotes from (CRB) were averaged on a weekly basis using the closing prices of each day. The Omaha cash corn price was acquired from USDA AMS, and the Thursday price of each week was used as a proxy for potential feed costs feedlots would realize to finish out the purchased feeder cattle. The same methods used to calculate $basiserror_t$ were also used to formulate $lccratioerr_t$. This variable was based on the difference between the actual ratio and expected ratio calculated using the prior three year average. Two and four year historical averages were also used to predict the expected ratio and used in the corresponding models. $lccratioerr_t$, $twoyrlcc_t$, and $fouryrlcc_t$ were calculated using equation (7).

The data for the profit and loss independent variable, pl, comes from CattleFax. A complex model is utilized to estimate the returns in dollars per head a cattle feeder would receive each week on a cash to cash basis assuming no risk management. A simple four-week, moving average is used for the three different models.

To represent the delivery costs, the independent variable $transportion$ is used as a proxy. The data was acquired from the Producer Price Index No. 2 diesel fuel series reported by the Bureau of Labor Statistics. This index is not seasonally adjusted and figured on a monthly basis. Therefore, there is some duplication of the data series in the models.

Descriptive statistics of all variables are in Table 6.2. Figure 6.1 shows the absolute value of two, three, and four year basis prediction error for Kansas. Cleary, the BPE levels became extreme in the recent years.

6.2 - Descriptive Statistics

Region	Variable	Units	Mean	St Dev	Min	Max	N
All Regions	$basiserror$	$/cwt	1.983	2.283	0.000	28.837	9,678
	Physical Delivery	$/cwt	1.631	1.241	0.000	7.575	1,758
	Cash Settlement	$/cwt	2.061	2.449	0.000	28.837	7,920
	$twoyrbasiserr$	$/cwt	2.088	2.423	0.000	28.933	9,678
	Physical Delivery	$/cwt	1.746	1.383	0.001	7.870	1,758
	Cash Settlement	$/cwt	2.164	2.592	0.000	28.933	7,920
	$fouryrbasiserr$	$/cwt	1.992	2.329	0.000	28.762	9,162
	Physical Delivery	$/cwt	1.416	1.114	0.004	6.348	1,530
	Cash Settlement	$/cwt	2.107	2.487	0.000	28.762	7,632
	$lccratioerr$	$/cwt:$/bu	6.743	5.735	0.006	37.096	9,678
	$twoyrlcc$	$/cwt:$/bu	6.440	5.550	0.009	35.760	9,678
	$fouryrlcc$	$/cwt:$/bu	6.985	5.658	0.001	37.059	9,162
	pl	$/head	-0.419	102.499	-591.909	384.179	9,678
	$transportation$	PPI Index	137.106	93.924	39.100	431.900	9,678
Kansas (*ks*)	$basiserror$	$/cwt	1.789	2.033	0.001	18.002	1,613
	Physical Delivery	$/cwt	1.532	1.142	0.007	5.742	293
	Cash Settlement	$/cwt	1.846	2.178	0.001	18.002	1,320
	$twoyrbasiserr$	$/cwt	1.903	2.149	0.001	19.522	1,613
	Physical Delivery	$/cwt	1.677	1.258	0.001	6.730	293
	Cash Settlement	$/cwt	1.954	2.297	0.003	19.522	1,320
	$fouryrbasiserr$	$/cwt	1.786	2.045	0.005	16.980	1,527
	Physical Delivery	$/cwt	1.331	1.041	0.019	5.508	255
	Cash Settlement	$/cwt	1.877	2.180	0.005	16.980	1,272
Missouri (*mo*)	$basiserror$	$/cwt	1.982	2.382	0.000	21.752	1,613
	Physical Delivery	$/cwt	1.666	1.279	0.005	7.575	293
	Cash Settlement	$/cwt	2.052	2.559	0.000	21.752	1,320
	$twoyrbasiserr$	$/cwt	2.080	2.533	0.000	23.897	1,613
	Physical Delivery	$/cwt	1.741	1.445	0.009	7.615	293
	Cash Settlement	$/cwt	2.155	2.711	0.000	23.897	1,320
	$fouryrbasiserr$	$/cwt	1.963	2.352	0.002	20.152	1,527
	Physical Delivery	$/cwt	1.431	1.106	0.013	6.348	255
	Cash Settlement	$/cwt	2.070	2.516	0.002	20.152	1,272
Nebraska (*neb*)	$basiserror$	$/cwt	2.182	2.511	0.000	27.092	1,613
	Physical Delivery	$/cwt	1.753	1.353	0.004	6.183	293
	Cash Settlement	$/cwt	2.278	2.693	0.000	27.092	1,320
	$twoyrbasiserr$	$/cwt	2.289	2.661	0.000	25.743	1,613
	Physical Delivery	$/cwt	1.877	1.532	0.001	7.870	293
	Cash Settlement	$/cwt	2.380	2.844	0.000	25.743	1,320
	$fouryrbasiserr$	$/cwt	2.229	2.632	0.000	27.424	1,527
	Physical Delivery	$/cwt	1.546	1.228	0.004	5.878	255
	Cash Settlement	$/cwt	2.366	2.811	0.000	27.424	1,272

North/South Dakota (*dk*)	$basiserror$	$/cwt	2.229	2.575	0.002	28.837	1,613
	Physical Delivery	$/cwt	1.782	1.290	0.005	5.397	293
	Cash Settlement	$/cwt	2.328	2.772	0.002	28.837	1,320
	$twoyrbasiserr$	$/cwt	2.368	2.757	0.000	28.933	1,613
	Physical Delivery	$/cwt	1.854	1.408	0.013	6.426	293
	Cash Settlement	$/cwt	2.482	2.963	0.000	28.933	1,320
	$fouryrbasiserr$	$/cwt	2.251	2.642	0.005	28.762	1,527
	Physical Delivery	$/cwt	1.500	1.182	0.019	5.473	255
	Cash Settlement	$/cwt	2.401	2.822	0.005	28.762	1,272
Oklahoma (*okla*)	$basiserror$	$/cwt	1.859	2.147	0.000	18.502	1,613
	Physical Delivery	$/cwt	1.525	1.153	0.000	5.658	293
	Cash Settlement	$/cwt	1.934	2.305	0.002	18.502	1,320
	$twoyrbasiserr$	$/cwt	1.965	2.256	0.003	20.772	1,613
	Physical Delivery	$/cwt	1.670	1.269	0.012	6.205	293
	Cash Settlement	$/cwt	2.030	2.416	0.003	20.772	1,320
	$fouryrbasiserr$	$/cwt	1.839	2.176	0.003	17.889	1,527
	Physical Delivery	$/cwt	1.303	1.040	0.006	5.133	255
	Cash Settlement	$/cwt	1.947	2.323	0.003	17.889	1,272
Texas (*tex*)	$basiserror$	$/cwt	1.856	1.943	0.003	18.419	1,613
	Physical Delivery	$/cwt	1.529	1.195	0.045	7.075	293
	Cash Settlement	$/cwt	1.929	2.066	0.003	18.419	1,320
	$twoyrbasiserr$	$/cwt	1.923	2.059	0.003	19.772	1,613
	Physical Delivery	$/cwt	1.658	1.361	0.004	7.115	293
	Cash Settlement	$/cwt	1.982	2.180	0.003	19.772	1,320
	$fouryrbasiserr$	$/cwt	1.882	2.004	0.001	17.277	1,527
	Physical Delivery	$/cwt	1.384	1.063	0.026	5.553	255
	Cash Settlement	$/cwt	1.982	2.130	0.001	17.277	1,272

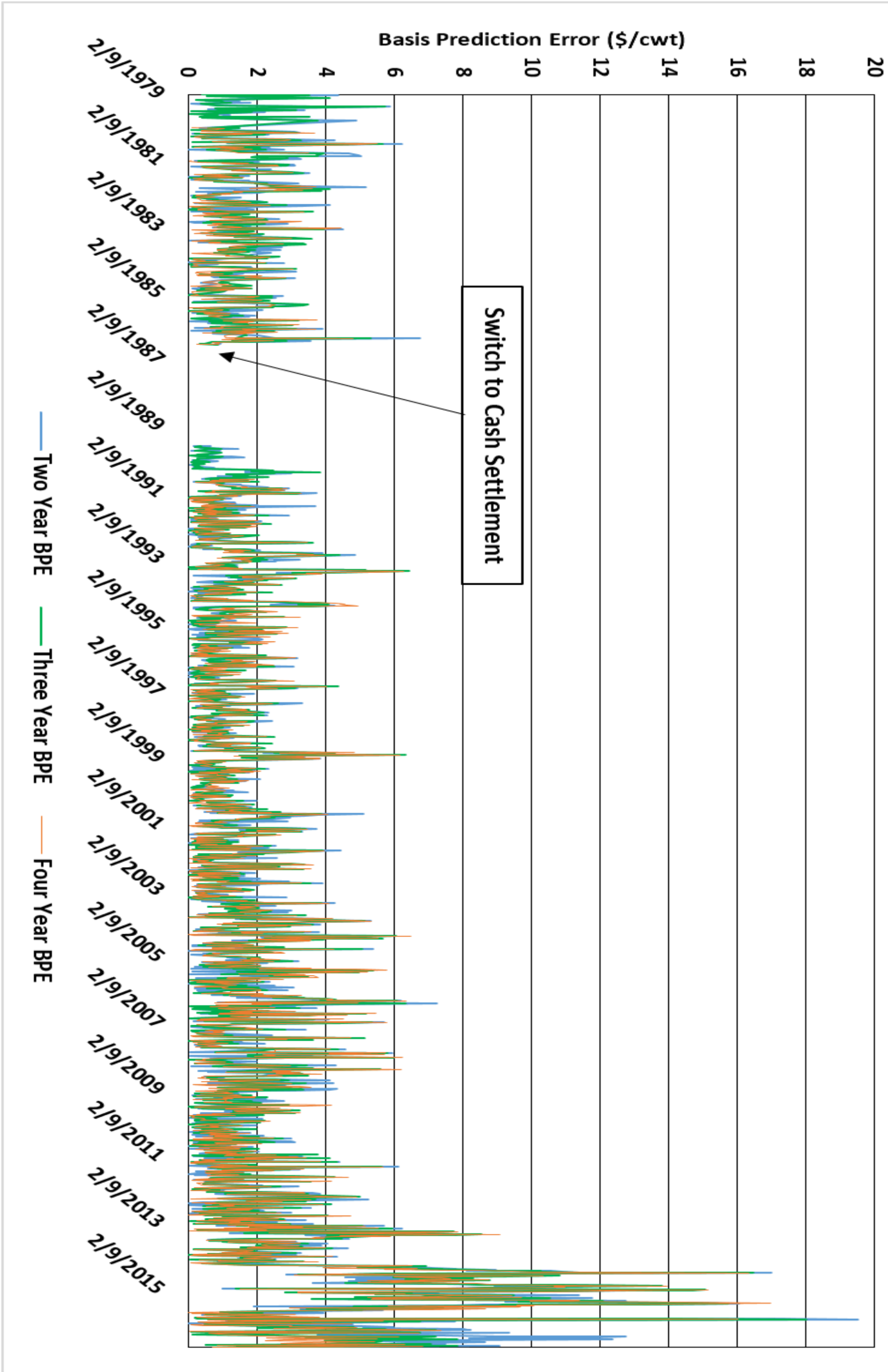


Figure 6.1 - Kansas Feeder Cattle Basis Prediction Error

Chapter 7 - Results and Discussion

7.1 Basis Prediction Error Model Results

Most of the discussion regarding the results will revolve around the model that included the three year historical basis prediction error ($basiserror$) and the same method for the live cattle and corn ratio error ($lccratioerr$). This is because of the findings Tonsor et al. (2004) discovered as the best simple approach to forecasting basis in the feeder cattle market. All other independent variables, besides $lccratioerr$, are the same for all three models. It is important to note the effect on $basiserror$, $twoyrbasiserr$, and $fouryrbasiserr$ is not whether the basis increases or decreases; rather the magnitude of how close the predicted basis will be relative to the actual basis.

Often times with time series data, one of the classical assumptions that satisfies ordinary least squares (OLS) regression is violated. That assumption is homoscedasticity and states the variance of the error term is constant across all observations. If the assumption is violated, meaning the error term is not constant, heteroscedasticity is present. Under heteroscedasticity, the OLS estimates are still unbiased and consistent, but not efficient. Also, the formula for the variances of OLS estimators is incorrect. As a result the standard errors, t-statistics, and P-values are invalid.

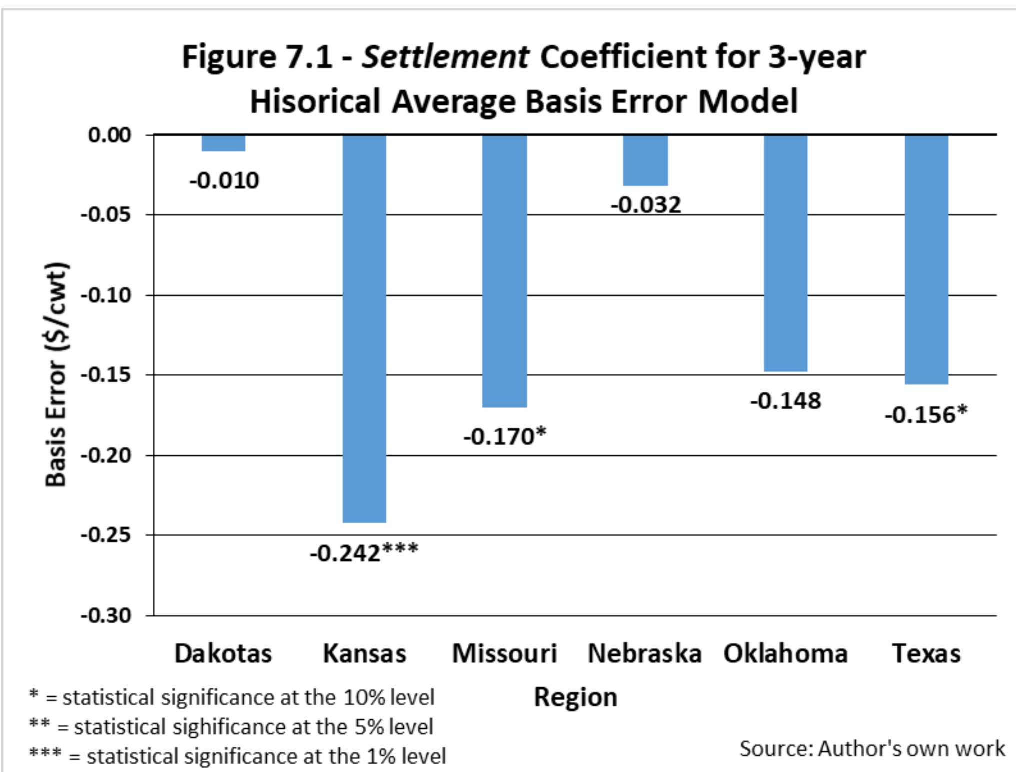
A Breusch-Pagan test, which uses the framework of the Lagrangian multiplier test, was performed on the estimate error to determine if homoscedasticity is violated (Breusch and Pagan, 1979). The STATA command estat hettest was used to test for heteroscedasticity after the OLS regression was performed. The null hypothesis is constant variance for the error terms. The results of the Breusch-Pagan test show the P-value is less than 0.001, so the variance is not constant for the error terms across all observations. To account for this, robust standard errors were used in this study. The OLS estimates are still inefficient; however, the t-statistics and P-values are valid.

The model was stacked to include all the observations from the six different regions equating to a total of 9,678. Table 7.1 displays the estimates, robust standard errors, and P-values for the model with $basiserror$ as the dependent variable. Multiple variables are statistically significant at the 0.01, 0.05, and 0.10 level. The R-squared value of the model is 0.1414, meaning approximately 14 percent of the basis prediction error variability is explained by the variables in the model.

Table 7.1 Three Year Historical Average Basis Prediction OLS Regression Results

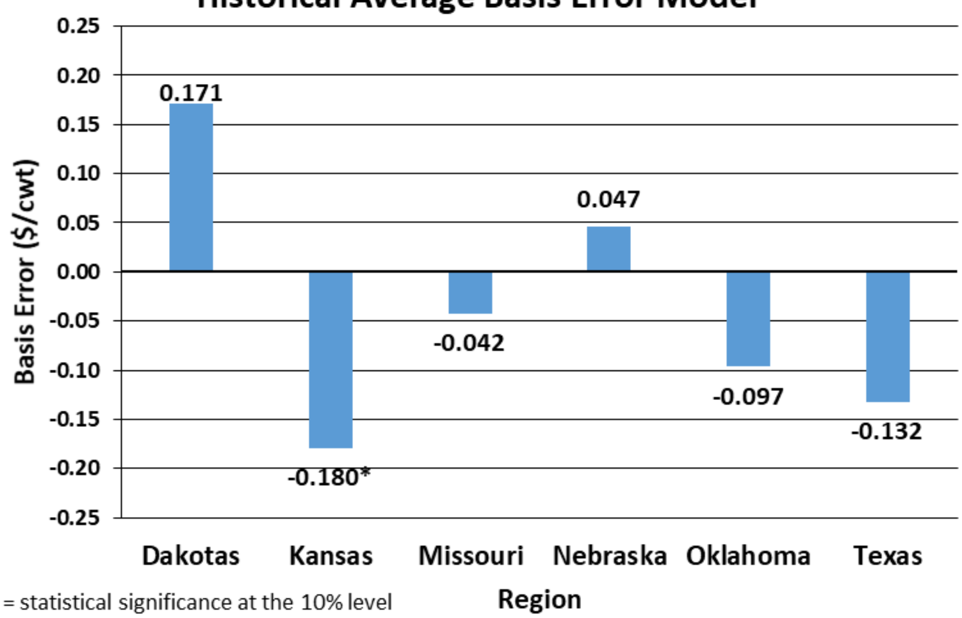
Variable	Units	Coefficient Estimate	Robust Std. Err.	P-Value (P>|t|)
Intercept		0.5475	0.0961	<0.000
settlement	$/cwt	-0.2424	0.0875	0.006
(Base= Physical Delivery)				
lccratioerr	$/cwt:$/bu	0.0722	0.0059	<0.000
pl	$/head	-0.0008	0.0004	0.057
transportation	PPI Index	0.0054	0.0002	<0.000
Calendar Month Binary Variables				
(Base= January)				
feb		0.3420	0.1033	0.001
mar		-0.1432	0.0794	0.071
apr		0.1186	0.0891	0.183
may		0.1354	0.0878	0.123
june		1.0808	0.1035	<0.000
july		0.6262	0.1136	<0.000
aug		0.0496	0.0977	0.612
sept		-0.1784	0.0878	0.042
oct		-0.3097	0.0814	<0.000
nov		-0.1356	0.0890	0.127
dec		0.6217	0.1098	<0.000
Region Binary Variables				
(Base= Kansas)				
okla		-0.0075	0.0950	0.937
tex		-0.0035	0.0952	0.971
neb		0.2204	0.1024	0.031
mo		0.1334	0.0998	0.181
dk		0.2499	0.1014	0.014
Interaction Terms				
okcs		0.0947	0.1247	0.448
txcs		0.0864	0.1225	0.481
necs		0.2108	0.1355	0.120
mocs		0.0724	0.1313	0.581
dkcs		0.2322	0.1354	0.086
Observations				9,678
Analysis of Variance and Homoskedasticity	**R-Squared**			0.1414
	Breusch-Pagan/Cook-Weisberg test		Prob > Chi sq.	<0.000
			DF = 24	Chi-Sq. = 6354.01

With Kansas (ks) as the default in the model, the cash settlement dummy variable ($settlement$) represents the direct effect the transition to cash settlement had on basis prediction error ($basiserror$) in Kansas. Based on the results, $settlement$ is statistically significant at the 0.01 level with a negative relationship with $basiserror$. The interaction terms can be used to help determine the effect cash settlement has had on basis prediction error ($basiserror$) in the other regions. Also, separate models were ran with each state as a default to confirm statistical significance. Missouri and Texas show a statistically significant (P-value < 0.10), negative relationship with $basiserror$ as seen in Figure 7.1. For Nebraska, Oklahoma, and the Dakota areas; $settlement$ is not statistically different than zero. However, the statistical significance for the $settlement$ coefficient for Oklahoma is just slightly above the 0.10 level. The statistically significant estimates are small in respect to total dollar value of a single 800 pound feeder steer. However, when put into perspective of a load of feeder steers it begins to add up. The largest estimate is for Kansas and is interpreted that cash settlement has reduced basis prediction error by -$0.24/cwt., *ceteris paribus*.



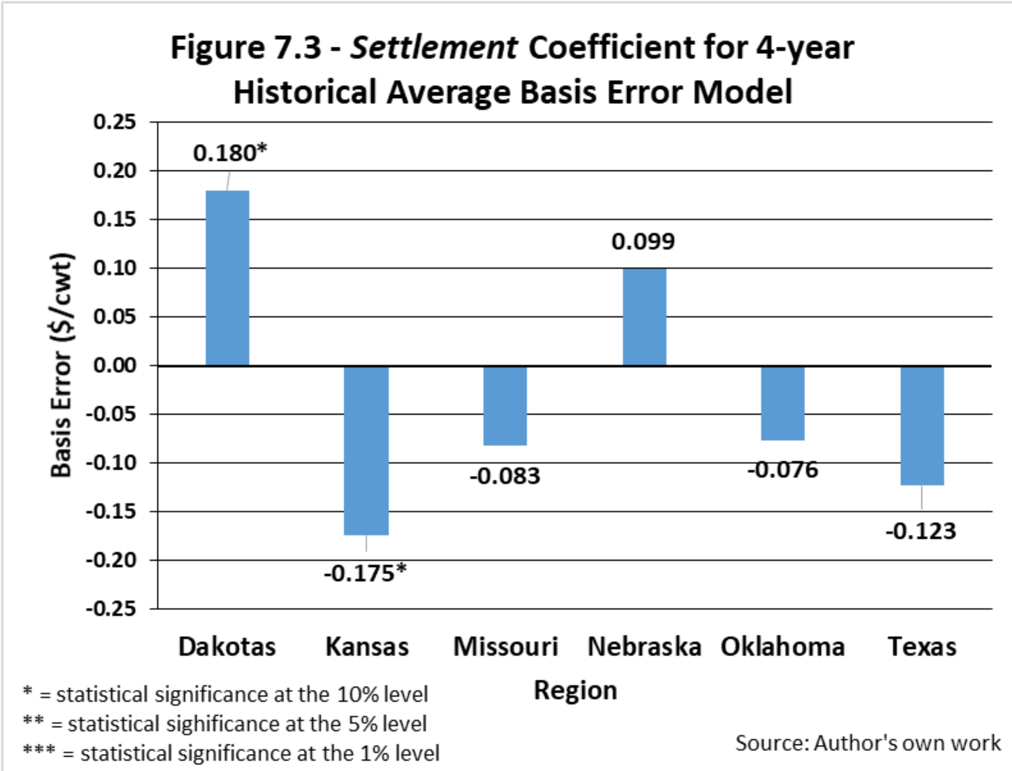
Models using the prior two and four year average basis to forecast expected basis for the corresponding week to expiration were also used to confirm the results previously discussed. The live cattle futures and cash corn ratio was calculated the same way and included in the respective models. For the two year historical model (Figure 7.2) with $twoyrbasiserr$ as the independent variable, Kansas is the only region where $settlement$ is statistically significant at the 0.10 level with a negative relationship to $twoyrbasiserr$. The coefficient is even smaller than the first model at -0.18. The other regions are statistically insignificant while Nebraska and the Dakotas actually have a positive coefficient. The results of the four year historical model (Figure 7.3), using $fouryrbasiserr$ as the independent variable, show some differences with respect to the first model. Once again, Kansas is the only region with a statistically significant and negative coefficient for $settlement$ with a value almost identical to the two year model. The result that is unique to this model is the fact that the $settlement$ estimate for the Dakotas region is positive and statistically significant at the 0.10 level. It is important to note the value is only 0.18, but it is still interpreted that the transition to cash settlement increased basis prediction error ($fouryrbasiserr$) in North/South Dakota by +$0.18/cwt., *ceteris paribus*.

Figure 7.2 - *Settlement* Coefficent for 2-year Historical Average Basis Error Model



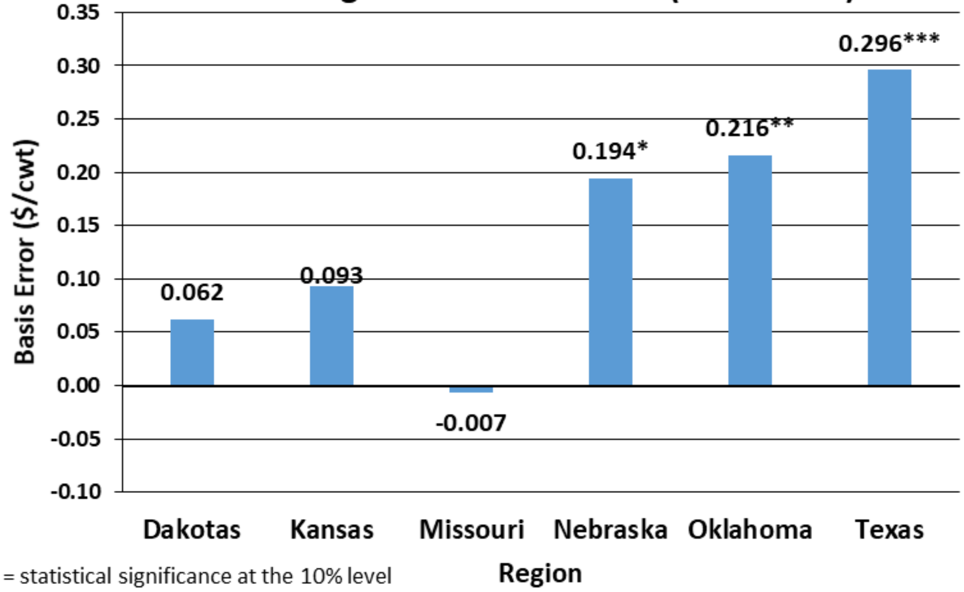
* = statistical significance at the 10% level
** = statistical sighificance at the 5% level
*** = statistical significance at the 1% level

Source: Author's own work



An additional model was ran for each of the methods used to calculate basis prediction with data between the years of 1981 to 1995. This was done to center the data around the time the transition to cash settlement took place. This is another way of further testing the effect the change had on basis prediction error. There is a possibility the $settlement$ dummy variable is a reflection through time of several different factors such as changes in cattle types, technology, breed mix, etc., and this is an attempt to isolate it more. Surprisingly, the results are vastly different as all but two coefficients are positive. Also, several of the estimates for the different regions are statistically significant. This would imply that the switch to cash settlement was not favorable to hedgers because it increased basis prediction error. It is critical to keep in mind some of the changes the settlement index went through over time. During most of this timeframe, the index was formulated from prices in 27 different states. It is difficult to confirm, but this may have had an impact on the markets.

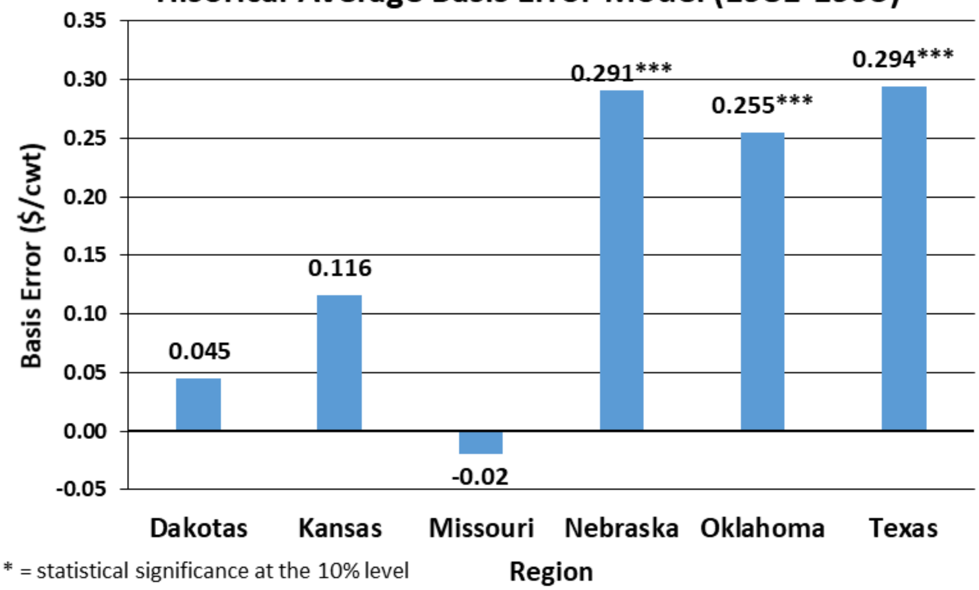
Figure 7.4 - *Settlement* Coefficent for 2-year Historical Average Basis Error Model (1981-1995)



* = statistical significance at the 10% level
** = statistical sighificance at the 5% level
*** = statistical significance at the 1% level

Source: Author's own work

Figure 7.5 - *Settlement* Coefficient for 3-year Hisorical Average Basis Error Model (1981-1995)



* = statistical significance at the 10% level
** = statistical sighificance at the 5% level
*** = statistical significance at the 1% level

Source: Author's own work

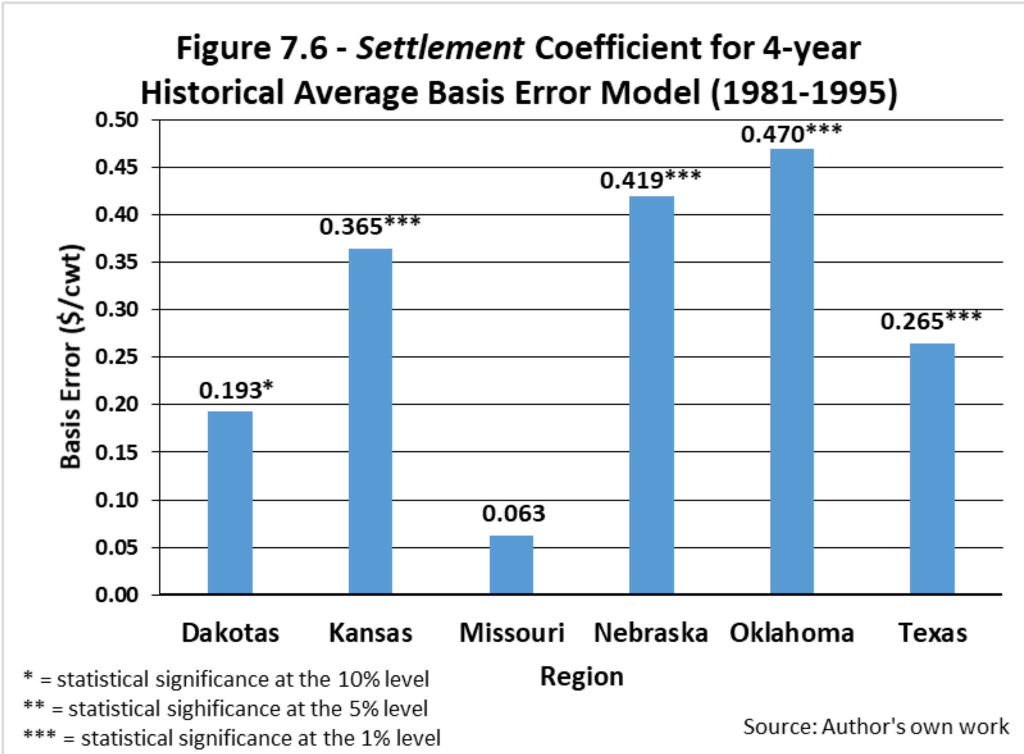


Figure 7.6 - *Settlement* Coefficient for 4-year Historical Average Basis Error Model (1981-1995)

The remaining discussion of the results will be from the model using all the years with the dependent variable being $basiserror$ which utilized the prior three year average to predict basis and calculate basis prediction error. The live cattle futures to cash corn price ratio error ($lccratioerr$) coefficient is statistically significant at the 0.01 level and positive. This means when the ratio of the deferred live cattle futures and spot corn price is different than the previous three year average, current basis prediction error ($basiserror$) will increase. This could occur if the live cattle futures increases or decreases relative to the corn price. The same would be true if the corn price increases or decreases with respect to the deferred live cattle futures. Once again, the effect on $basiserror$ is fairly small at 0.072. This means a one unit increase in the live cattle to corn ratio error would increase basis prediction error $0.072/cwt., *ceteris paribus*.

The variable pl, which estimates the previous four week average profit or loss ($/head) of fed cattle, is statistically significant at the 0.10 level with a negative coefficient of -0.0008. The effect feedlot profitability has on $basiserror$ is essentially economically insignificant due to the miniscule value. It is interpreted that a $1.00 per head increase in prior profits would reduce basis prediction error ($basiserror$) by less than one cent per cwt. or $0.0008/cwt. to be exact, *ceteris paribus*.

As a proxy for delivery costs associated with buying feeder cattle, the variable $transportation$ was used. The coefficient for the right hand side variable is positive and statistically significant at the 0.01 level. This variable is measured using an index of diesel fuel price. It can be interpreted that basis prediction error ($basiserror$) increases by $0.005/cwt. with a one unit increase of the index, *ceteris paribus*. Bottom line, the model results indicate as transportation costs, in particular fuel prices, increase the ability to accurately forecast basis becomes more difficult.

To measure seasonality of basis prediction error, dummy variables for each calendar month were included in the model with January set as the default. To no surprise, the four off-contract months (February, June, July, and December) have a positive relationship with $basiserror$, and all are statistically significant at the 0.01 level. June has the most substantial effect on basis prediction error. During the month of June, one would expect the forecasted basis, to be wrong by approximately $1.08/cwt. compared to January, *ceteris paribus*. March, September, and October have a negative relationship with $basiserror$ and are statistically significant at the 0.10, 0.05, and 0.01 level, respectively. October has the most negative impact on basis prediction error compared to January with a value of -0.31.

Binary variables denoting each region, with Kansas as the default, were used to determine if $basiserror$ was impacted in the different areas. Both Nebraska and North/South Dakota have a positive estimate of 0.22 and 0.25, respectively, and are significant at the 0.05 level. It would be expected that basis is more difficult to predict in these two areas compared to Kansas.

To further test the results from the model that was previously discussed, two and four year historical averages were used to calculate expected basis. The results from the models using two and four year historical averages to calculate predicted basis and the live cattle to corn ratio error can be found in Appendix A.

7.2 Basis Prediction Error Model Discussion

The results from the model provides some useful insight on the effect cash settlement has had on the ability to predict basis as well as some of the other factors that ultimately impact basis prediction error. For the most part, the estimates are in line with what was expected and previously discussed. This section will review why there may be some differences.

The three different models have some varying results regarding the effect cash settlement had on basis prediction error, with the exception of Kansas. In fact, a couple states, Oklahoma and Nebraska, never showed a statistically significant difference in basis error between the two different time periods for any of the models. Surprisingly, when using the prior four year basis average to calculate predicted basis, North/South Dakota actually indicated cash settlement increased basis error. Because the data was aggregated across a two state area, the results may not be the best representation of how cash settlement has truly impacted basis forecasting at the local level in that region. This North/South Dakota result is similar to those found by Kenyon et al. (1991), who concluded standard deviation of basis prediction error increased after the transition to cash settlement in Virginia markets. Tonsor et al. (2004) also discovered basis prediction error increased at one market location in Kansas, but this result was offset by a variable declaring basis became easier to forecast as time went on. When analyzing the findings from all three models, the conclusion Rich and Leuthold (1993) made that the impacts of cash settlement vary across locations best describes the results of this study.

The variables $lccratioerr$ and $transportation$ supported the expectations of positively impacting basis prediction error that were discussed previously. The results of $lccratioerr$ go along with Trapp and Eilrich (1991) in regards to live cattle futures and corn prices having a significant impact on feeder cattle basis.

It was difficult to hypothesize how exactly the prior profitability of feedlots (pl) would effect basis prediction error. According to the estimates, the higher the margins for cattle feeders during the previous four weeks, the easier it is to forecast the feeder cattle basis. Even though the value is miniscule, this could be due to the fact that feedlot managers will not fight the feeder cattle market as much when they have recently made money and pay the price for feeder cattle that makes the basis consistent with the three years before.

The seasonality of basis prediction error, measured by calendar month dummy variables, responded the way it was hypothesized regarding off contract months.

According to the regional dummy variable estimates, prediction basis error is expected to be larger in the northern most areas compared to Kansas. The Dakotas show the most substantial impact on basis error, and this could be due to the additional distance the feeder cattle would have to travel to get to the heart of cattle feeding country. It is difficult to determine why Nebraska indicates the increase in basis prediction error relative to Kansas.

7.3 Basis Direction Model Results

The results of an additional model attempting to predict the directional impact some of the variables, especially the live cattle to corn ratio, may have on basis will also be examined. This model sets actual basis in Kansas as the dependent variable ($basis$), and the actual deferred live cattle futures to spot corn ratio is used ($lccratio$). The other independent variables remain the same, excluding the regional binary variables and interaction terms. The estimates found in Table 7.2 indicate whether the variable strengthens or weakens feeder cattle basis in Kansas.

Table 7.2 - Actual Kansas Basis OLS Regression Results

Variable	Units	Coefficient Estimate	Robust Std. Err.	P-Value (P>|t|)
Intercept		-5.561	0.381	<0.000
$settlement$	$/cwt	2.283	0.133	<0.000
(Base= Physical Delivery)				
$lccratio$	$/cwt:$/bu	0.103	0.011	<0.000
pl	$/head	0.002	0.001	0.079
$transportation$	PPI Index	0.008	0.001	<0.000
Calendar Month Binary Variables				
(Base= January)				
feb		0.761	0.317	0.016
mar		0.735	0.261	0.005
apr		1.074	0.285	<0.000
may		1.173	0.289	<0.000
$june$		0.524	0.327	0.110
$july$		0.734	0.318	0.021
aug		0.133	0.287	0.643
$sept$		0.152	0.276	0.583
oct		-0.280	0.271	0.302
nov		0.065	0.306	0.831
dec		0.352	0.336	0.295
Observations				1,613
Analysis of Variance and Homoskedasticity	**R-Squared**			0.3254
	Breusch-Pagan/Cook-Weisberg test		Prob > Chi sq.	<0.000
			DF = 15	Chi-Sq. = 699.27

The statistically significant $settlement$ estimate indicates basis is $2.28/cwt. stronger when the feeder cattle contract is cash settled compared to physical delivery. This is also supported by the mean basis difference of approximately +$3.46 during cash settlement compared to physical delivery.

The $lccratio$, pl, and $transportation$ variables are statistically significant with a positive relationship with $basis$. Based on these findings, as the live cattle to corn ratio increases by one unit, basis should strengthen by +$0.10/cwt. Therefore, it could be assumed if the nominal value of the ratio error is positive (current ratio is greater than expected ratio), then actual basis would be stronger than expected basis. This would likely happen since the deferred live cattle futures would be increasing relative to current corn prices. As a result, feedlots would become more optimistic and willing buyers. The opposite impact on basis could occur if the ratio error is negative.

The estimate for the prior month profitability of feedlots (pl) is positive, but substantially small being 0.0019. The interpretation is if there is a dollar per head increase in prior profits for feedlots, then basis for feeder cattle would strengthen by +$0.002/cwt. This could likely happen since cattle feeders recently made money and are potentially willing to pay higher prices for feeder cattle as a result. The variable $transportation$ has a small value of 0.008, meaning as diesel fuel costs increase, basis strengthens by +$0.008/cwt. in Kansas. Since Kansas is a large cattle feeding state, a significant number of feeder cattle have to be imported from other regions of the country to supply enough cattle to fill the feedlots. This could help explain why basis increases in Kansas when fuel prices rise. Feedlots would be willing to pay extra for the local supply in Kansas rather than pay higher delivery costs to transport cattle from different areas of the U.S.

The calendar month dummy variables simply display the seasonality of feeder cattle basis in Kansas. One would expect the strongest basis to be in the Spring months of May and April, respectively.

Chapter 8 – Conclusion

As time has progressed, the agriculture commodity markets, especially cattle markets, have become more volatile; increasing price risk for both buyers and sellers. There are many strategies that can be implemented to manage risk. One of the most popular risk management tool is utilizing the futures contract of the underlying commodity. The strategy can be as simple as a basic hedge, or to take a position in the futures market to capture margin from a potential price move that goes against the current commercial position. Without an effective futures contract that accurately represents the underlying product, hedging may become ineffective leading to declining participation in the futures market by both commercial users and speculators. Future exchange organizations have continually worked through history to make adjustments to futures contract specifications and even changed settlement procedures to ensure the contracts perform at the highest level pertaining to risk management.

Discussions regarding the effectiveness of the live cattle futures contract traded on the Chicago Mercantile Exchange (CME) platform started as early as the 1980's and is still a relevant topic today in the industry. Some individuals and organizations in the industry proposed the idea of switching from physical delivery to cash settlement to enhance the contract. There has been two futures contracts that made that particular transition. The feeder cattle contract made the change in September 1986, while the live hog contract was replaced by the cash settled lean hog contract in February 1997. This study was conducted to compare the hedging ability, in particular basis predictability, of the feeder cattle contract during physical delivery and cash settlement in hopes to determine the optimal settlement procedure and provide insight for further decisions regarding potential changes to other contracts. It is important to note the feeder cattle contract represents a sector of the industry that is vastly different when compared to the live cattle contract.

Basis prediction error (BPE) defined as the difference between expected basis and actual basis was used to measure the hedging effectiveness of the feeder cattle contract. Feeder cattle cash prices from six different regions from the Central Plains of the United States, aggregated on a per region base, were used to calculate BPE. Basis is commonly forecasted using an average of prior years for a particular week, either calendar week or week to expiration. In this study, basis was forecasted using a two, three, and four year historical average. However, Tonsor et al. (2004) concluded the most accurate technique, when using a simple method, to forecast basis in the feeder cattle market is by way of the three year historical average.

8.1 Results of Basis Prediction Error Models

Three different stacked models for each of the different forecasting techniques were used that included the data from all six regions. An OLS regression approach using robust standard errors, with BPE as the dependent variable, was used to estimate the results. The results indicated the effects cash settlement had on hedging ability, depended on the region and the method used to forecast basis. Kansas, Missouri, and Texas show a reduction in BPE during cash settlement compared to physical delivery when a three year historical average was utilized to forecast basis. The two year historical method results only had one region, Kansas, with a significant decrease in BPE after the transition. When the four year strategy to forecast basis was used, the results display Kansas had a reduction in BPE while North/South Dakota actually showed an increase in BPE during cash settlement relative to physical delivery.

Other variables were included in the models to attempt to capture the factors that affect BPE. Since the three year historical average technique is considered the optimal way, the results discussed will come from those estimates where Kansas is set as the default region. Basis prediction error is sensitive to an output and input price ratio. A deferred live cattle futures price to cash corn price ratio error, calculated the same as BPE, was used to measure the impact the ratio difference would have on the ability to predict basis. It is expected as the deferred live cattle quotes increase (decrease) relative to corn prices compared to historical averages, basis will be stronger (weaker) than expected. Although, the coefficient is small, it shows the live cattle prices and factors effecting breakeven prices impact feeder cattle basis.

Both the prior four week profitability of feedlots and transportation costs have an impact on BPE. The previous month's margins experienced by feedlots on a per head basis had a minimal, but negative relationship with BPE. This was used as a behavioral economic factor in an attempt to measure the current psychology of the cattle feeders. Delivery costs, with a diesel fuel price index as a proxy, showed a miniscule positive impact on BPE. These variables highlight the effects current economics can have on the ability to forecast basis.

The linear regression results of the calendar month binary variables show the seasonality of BPE. As expected, hedgers need to be cautious with the variation of BPE during the four off contract months. During February, June, July, and August, it would not be uncommon for basis error to be as much as $1.00/cwt. higher compared to the BPE in January. Three of the contract months (March, September, and October) show a reduction in BPE relative to January which is encouraging for hedgers.

Regional results indicate the further north feeder cattle are sold relative to Kansas, there is an increase in BPE. This is most likely due to the added delivery costs associated with transporting the feeder cattle to the higher concentrated feedlot area.

8.2 Model Limitations

This research was done to provide industry stakeholders with insight on how the transition to cash settlement has improved the feeder cattle contract in regards to hedging ability. The main limitation is the feeder cattle cash prices were aggregated on a state or regional basis which does not allow hedgers to analyze the implications on a local level. There could be a significant difference in basis from the eastern and western markets in the same state. Also, due to a lack of a consistent volume of feeder cattle sales in certain regions of the country, many areas were not included in the research. Because of these limitations, a definitive conclusion cannot be made about whether hedging ability has improved because of cash settlement for all markets of the United States. An assumed one to one hedging ratio was used, so there is no evidence about how cash settlement has impacted the risk management for multiple weights of feeder cattle or calves.

Obviously, there are limitations for some of the other explanatory variables. The corn price is certainly a proxy for all areas as grain prices can have large variations from region to region depending on local supply and demand factors. The distances the feeder cattle travel after being procured is unknown and could provide a more in depth perspective on how much transportation costs truly impact basis.

8.3 Summary

The primary focus of this research was to analyze the impact the change to cash settlement had on the hedging effectiveness of the feeder cattle contract to encourage participation of commercial users. According to the results, a firm determination cannot be made that cash settlement has in fact improved the ability to hedge feeder cattle for all markets. Although, there is certainly some estimates that support cash settlement over physical delivery. The main takeaway from this study is that the effects are dependent upon the region and the method used to forecast basis. However, since only one area indicates a significant increase to basis prediction error, it is likely for cash settlement to have a favorable to no change in hedging ability. Also, it is vital that substantial amounts of research is done regarding the optimal index framework before cash settlement is implemented into futures contracts.

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Appendix A – Two and Four Year Historical Average Basis Forecast Models

Table A.1 - Two Year Historical Average Basis Prediction OLS Regression Results

Variable	Units	Coefficient Estimate	Robust Std. Err.	P-Value (P>|t|)
Intercept		0.6376	0.1020	<0.000
$settlement$	\$/cwt	-0.1795	0.0939	0.056
(Base= Physical Delivery)				
$twoyrlcc$	\$/cwt:\$/bu	0.0519	0.0059	<0.000
pl	\$/head	-0.0018	0.0004	<0.000
$transportation$	PPI Index	0.0059	0.0003	<0.000
Calendar Month Binary Variables				
(Base= January)				
feb		0.4102	0.1099	<0.000
mar		-0.0615	0.0846	0.467
apr		0.1639	0.0939	0.081
may		0.2311	0.0933	0.013
$june$		1.2412	0.1107	<0.000
$july$		0.7544	0.1231	<0.000
aug		0.0491	0.1038	0.636
$sept$		-0.1788	0.0892	0.045
oct		-0.2961	0.0833	<0.000
nov		0.0032	0.0932	0.973
dec		0.5936	0.1159	<0.000
Region Binary Variables				
(Base= Kansas)				
$okla$		-0.0069	0.1020	0.946
tex		-0.0194	0.1046	0.853
neb		0.2001	0.1128	0.076
mo		0.0638	0.1087	0.557
dk		0.1774	0.1090	0.104
Interaction Terms				
$okcs$		0.0830	0.1337	0.535
$txcs$		0.0476	0.1332	0.721
$necs$		0.2262	0.1475	0.125
$mocs$		0.1372	0.1423	0.335
$dkcs$		0.3510	0.1457	0.016
Observations				9,678
Analysis of Variance and Homoskedasticity	**R-Squared**			0.1239
	Breusch-Pagan/Cook-Weisberg test	Prob > Chi sq.		<0.000
		DF = 24		Chi-Sq. = 5076.60

Table A.2 - Four Year Historical Average Basis Prediction OLS Regression Results

Variable	Units	Coefficient Estimate	Robust Std. Err.	P-Value (P>|t|)
Intercept		0.3905	0.0989	<0.000
settlement	$/cwt	-0.1747	0.0907	0.054
(Base= Physical Delivery)				
fouryrlcc	$/cwt:$/bu	0.0946	0.0066	<0.000
pl	$/head	-0.0004	0.0004	0.316
transportation	PPI Index	0.0051	0.0002	<0.000
Calendar Month Binary Variables				
(Base= January)				
feb		0.3534	0.1088	<0.000
mar		-0.2059	0.0827	0.013
apr		0.1235	0.0929	0.184
may		0.1094	0.0913	0.231
june		0.9298	0.1065	<0.000
july		0.5458	0.1165	<0.000
aug		-0.0564	0.1000	0.573
sept		-0.2446	0.0925	0.008
oct		-0.4407	0.0840	<0.000
nov		-0.2384	0.0914	0.009
dec		0.6772	0.1124	<0.000
Region Binary Variables				
(Base= Kansas)				
okla		-0.0284	0.0983	0.772
tex		0.0533	0.0955	0.577
neb		0.2149	0.1026	0.036
mo		0.1005	0.0994	0.312
dk		0.1691	0.1036	0.103
Interaction Terms				
okcs		0.0983	0.1282	0.443
txcs		0.0515	0.1239	0.678
necs		0.2740	0.1380	0.047
mocs		0.0921	0.1312	0.483
dkcs		0.3548	0.1385	0.010
Observations				9,162
Analysis of Variance and Homoskedasticity	**R-Squared**			0.1585
	Breusch-Pagan/Cook-Weisberg test		Prob > Chi sq.	<0.000
			DF = 24	Chi-Sq. = 6656.86