

An analysis of economic factors affecting corn basis in Southwest Kansas

by

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Abstract

The region of Southwest Kansas will be experiencing growth in both beef and dairy production in the coming years. Additionally, there are also concerns with ground water availability for corn production in the area for the long run. Southwest Kansas most years is already a corn deficit area and with growing demand of corn and corn silage for feed, corn basis in the region is expected to strengthen. Familiarity with local corn basis is crucial for producers, grain merchants, and end-users to optimize their business decisions. This study examines potential outcomes for corn basis impacts based on the anticipated structural changes in the region.

To examine these changes, OLS Models were developed to specifically observe changes in total cattle inventory, corn acres, and corn silage acres, to measure impacts on corn basis as a dependent variable. First however, grain elevators in the region were analyzed to determine which ones to model for, and which modeled elevators would be the most valuable. The relationships of 30 grain elevators' corn basis values in the region were observed, and it was concluded that they were mostly highly correlated, suggesting a highly related market in the area and that similar factors were all explaining basis in the region. Other background information for the region and insights from the data were also explored throughout the paper. Lastly, data transformations and some proxies and assumptions had to be implemented for the data since not all variables were always complete and clean.

The results of the study indicated that the selected variables to explain corn basis, which included nearby corn futures, cattle inventory, planted corn acres, corn silage acres, diesel prices, and monthly time fixed effects, explained 76% of the variation in corn basis on average for the southwest Kansas regional models that were implemented. The RMSE's were slightly higher

than ideal ranging from 0.249 to 0.268, however, prior literature has noted that in recent years, it may be more difficult to forecast basis with lower error terms in general. Also, previously as noted, the data isn't perfect, with some proxies in place, which may contribute to the higher RMSE's as well. Nevertheless, with these results potential impacts on basis can be forecasted. A median forecast for changes in silage acres, and the anticipated future change in total cattle inventory is an impact of corn basis strengthening by \$0.29/bu.

The potential impacts discussed in this study are valuable for all parties involved in the corn supply chain in Southwest Kansas. Econometric models have some drawbacks, and complete accuracy is never ensured with any forecasting methods. However, the results in this paper provide a data driven method, and potential impacts to anticipate in the future.

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Chapter 1 - Introduction

1.1 Background

The region of Southwest Kansas is prominent for agriculture in the state of Kansas. The area is described as semiarid and is favorable for livestock production. The High Plains or Ogallala Aquifer also covers most of this region, and it provides water for municipal, industrial, and largely agricultural use for livestock and irrigation. Irrigation use in the area is widely used for corn production, which is converted to feed for livestock in the area. There is evidence to suggest that changing structural dynamics are occurring and likely will continue to occur for the region in the future. At the time of this writing, resources and markets are changing, and this can have significant impacts for the area.

The livestock industry in Southwest Kansas is sizeable. In 2024, on the 1st of January, the state of Kansas ranked 3rd nationally in total cattle population at 6.15 million head, making up 7.06% of all cattle in the U.S. In the same year, Kansas trailed Nebraska at 6.25 million head and Texas at 12 million, with these two states holding 7.17% and 13.77% of all cattle in the U.S, respectively. The identified Southwest Kansas region, specifically for this study, roughly holds 45% of the cattle population in the state. In 2024, this area held approximately 2.78 million head, which would place Southwest Kansas 10th nationally out of all the States. This information was sourced from the United States Department of Agriculture (USDA), National Agricultural Statistics Service (NASS). Figure 1.1. illustrates the defined Southwest Kansas Region that will be referred to throughout the rest of the study.

Figure 1.1. Southwest Kansas Region

Southwest Kansas Counties



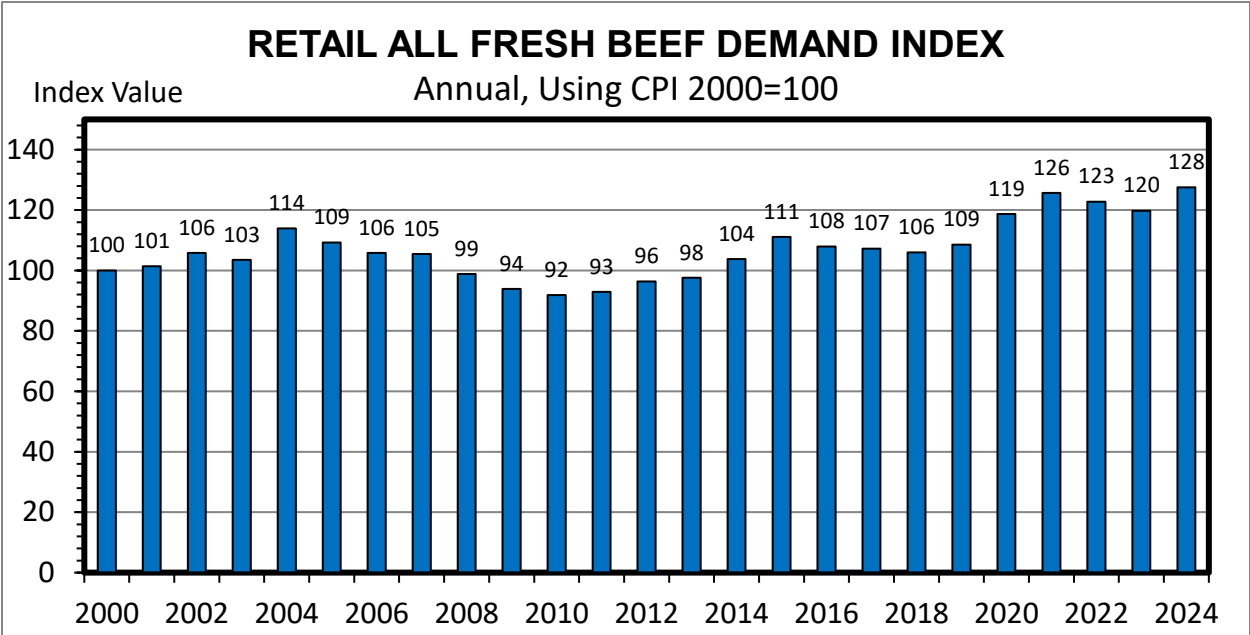
Sources: TIGER/Line via tigris

The state of Kansas also ranked 3rd in commercial cattle processed at 8.2 million head in 2023 (KLA). Southwest Kansas specifically processes most of the state’s total commercial cattle in the “Golden Triangle” or the towns of Garden City, Dodge City, and Liberal, which form a triangle shape on a map. Each packing plant provides 2,000 to 3,000 jobs, in which a significant proportion are held by immigrants. The packing plants have also encouraged the expansion of feedlots in the surrounding area. This increased economic activity in the area, relative to other rural areas in Kansas, is what coined the term “The Golden Triangle”. The four major meat packing companies that reside in these towns are Tyson near Garden City, Cargill Beef in Dodge City, and National Beef both in Dodge City and Liberal. These packing plants each have slaughter capacities of approximately 6,000 head per day or approximately 30,000 per 5-day week.

The culmination of this information signifies the strong beef cattle industry present in Southwest Kansas. This market is also positioned for future growth. In 2025, a prominent livestock feeding company, in central and western Kansas, Innovative Livestock Solutions, committed to building a new 88,000 head capacity feedlot (Service). This will be in Pawnee County, and at full capacity, it will more than double the county's current total cattle inventory (USDA NASS).

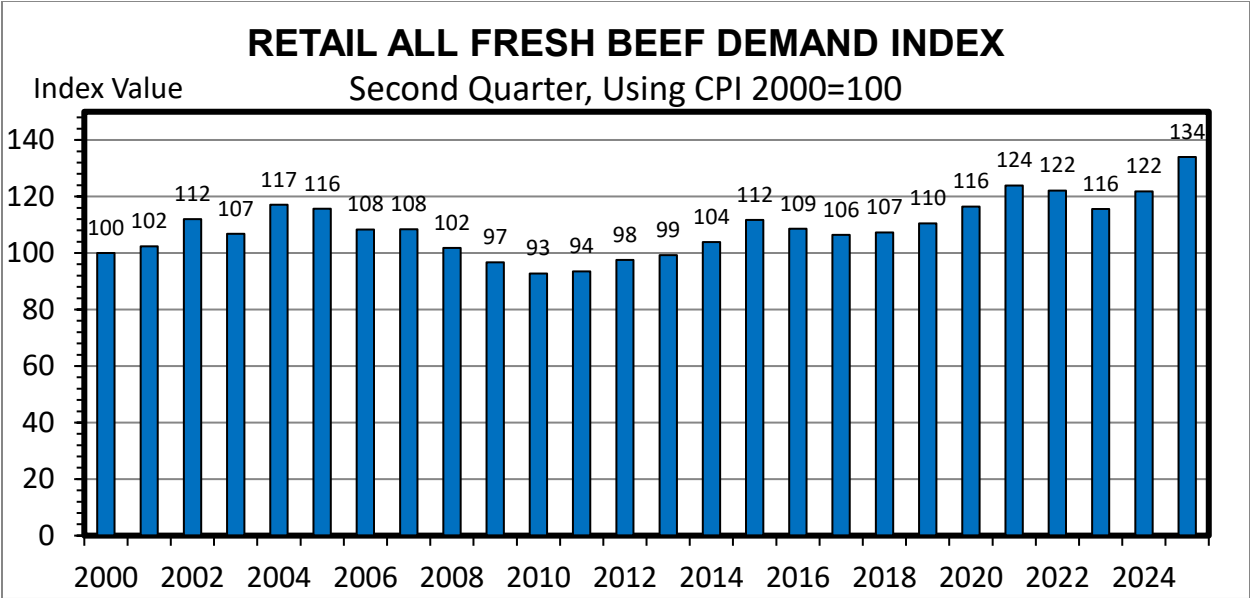
Demand for beef is also favorable and has experienced growth in recent years. Improvements such as beef marbling, thanks to greater genetics in cattle herds, have contributed to a higher-quality product. At the time of this writing in 2025, 87% of total production in the U.S. was Choice grade or higher. Additionally, consumer preferences have shifted to favor higher protein diets, which has also contributed to a higher demand for beef (Earnest). Figure 1.2. and 1.3. illustrate a retail all-fresh beef demand index developed by the Livestock Marketing Information Center (LMIC). The index is calculated by utilizing USDA's Economic Research Service's average retail fresh beef values, a calculated beef per capita consumption, the consumer price index (CPI) from the U.S. Bureau of Labor Statistics to adjust for inflation, and an own-price elasticity for beef of -0.479 reported by Tonsor, Lusk, and Schroeder in 2018 (Cozzens). Figure 1.2. is an annual comparison, while figure 1.3. incorporates the most recent data at the time of this writing, the second quarter of 2025 in this case, to give an indication of the most recent beef demand.

Figure 1.2. Annual Retail All Fresh Beef Demand Index (LMIC)



Source: Bureau of Labor Statistics, USDA-ERS, Compiled & Analysis by LMIC
Livestock Marketing Information Center

Figure 1.3. Second Quarter Retail All Fresh Beef Demand Index (LMIC)

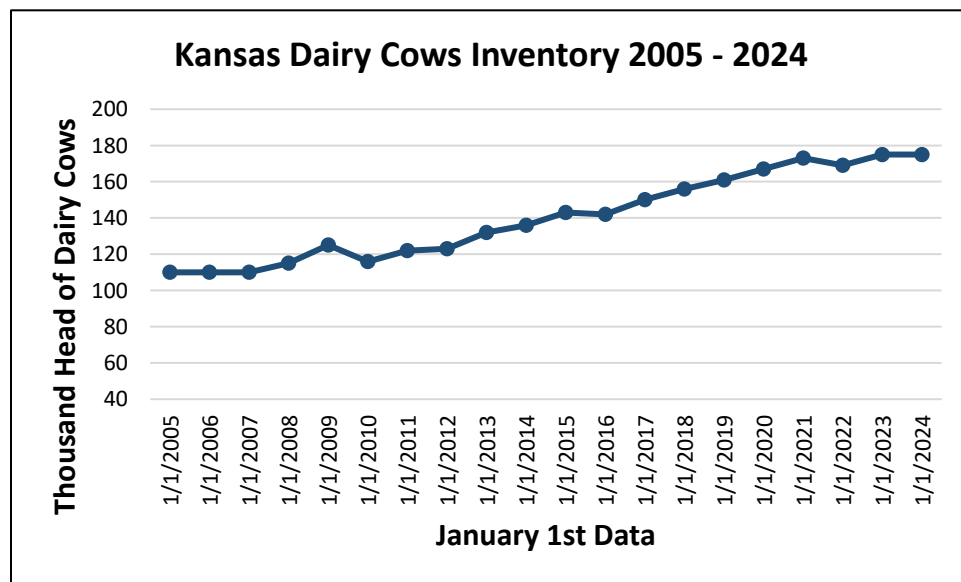


Source: Bureau of Labor Statistics, USDA-ERS, Compiled & Analysis by LMIC
Livestock Marketing Information Center

As figure 1.2. and 1.3. suggest, beef demand has noticeably elevated since 2020, and after the second quarter of 2025, an assumption can be made that this elevated demand is continuing. Altogether, with current feedlot expansion taking place and favorable beef demand, Southwest Kansas has confirmed growth and may even potentially see further growth in the future for cattle production.

Not only is beef cattle production strong and increasing in the area, but we can also deduce a strong and growing dairy industry as well. In 2024, on the first of January, the state of Kansas's total dairy cow inventory was 175,000 head, 17th nationally. In 2015, it was 143,000; the past 10 years have experienced consistent growth on a state level (USDA NASS). Figure 1.4 illustrates the growth of dairy cattle in Kansas for the last 20 years.

Figure 1.4. Annual Kansas Dairy Cattle Inventory (USDA, NASS)



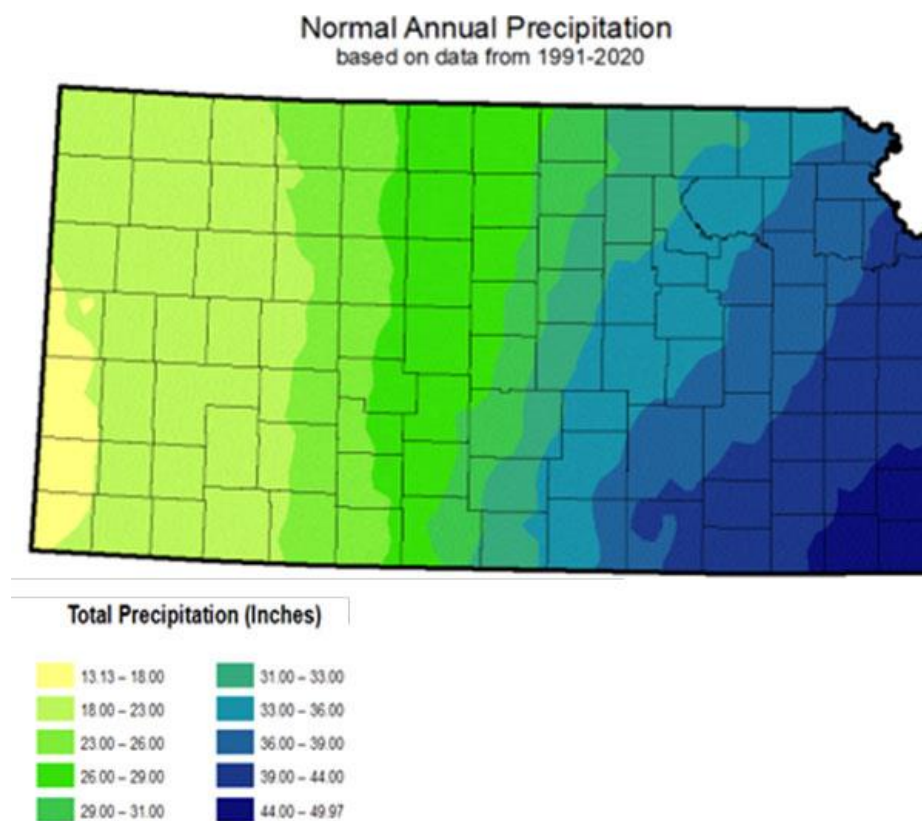
Source: USDA NASS

USDA does not provide granular data for county or an area region such as Southwest Kansas for dairy cattle. However, based on anecdotal observation, a substantial proportion of the state's total dairy cattle inventory is held in Southwest Kansas. The growth of dairy processing plants in the area supports this and encourages future growth in dairy farms in the area as well. In 2013, in Hugoton, Kansas, Kansas Dairy Ingredients (KDI) opened an ultrafiltered milk and dairy processing plant (Schroeder). It had an initial processing capacity of approximately 1 million pounds of dairy products per day (Dairy, cheese plant). Then eventually expanded to a 2.5 million pounds daily capacity (Kansas dairy ingredients). In 2017, (DFA) Dairy Farmers of America Cooperative opened a new dairy ingredients processing plant in Garden City. It has a daily processing capacity of 4 million pounds of milk, which equates to the output of 80,000 dairy cows from a total of 21 dairies in the region (Davis). In 2024, KDI in Hugoton closed its doors, but its processing facility was purchased by Flora Food Company. Flora Food Company plans to reopen the facility after additional investments to the site are made (Flora Food Group). Lastly, California-based Hilmar Cheese Company, in mid-2025, opened a cheese plant in Dodge City. This facility was an investment of over \$600 million and created 250 new jobs. "We chose to build in Dodge City because of the local and skilled labor force, supportive and expanding agricultural region, and excellent transportation network," David Ahlem, President and CEO of Hilmar, stated (Bohnert). The facility has a capacity of approximately 260 tanker trucks of milk per day, which is the equivalent of the production of 110,000 dairy cows (Wilson). Given this information, this confirms the strong dairy presence in Southwest Kansas and its growing trajectory.

The strong livestock presence in this area, as discussed, demands a lot of feed, and corn is the primary feed ingredient for most rations. In 2024, the state of Kansas planted 6.3 million

acres of corn, while the southwest region was calculated in this study to have approximately 1.44 million planted acres. Irrigation in this region is crucial to help meet the strong demand for corn, especially since average rainfall in the area is lower compared to the rest of the state. Corn grown in Kansas has growing season water use requirements ranging between 20-31.6 inches (Ciampitti, et al). Figure 1.5., table 1.1, and table 1.2 highlight average rainfall in Kansas from 1991-2020 and illustrate the importance of irrigation use for water requirements for corn in Southwest Kansas.

Figure 1.5. Annual Precipitation Map of Kansas (Sittel)



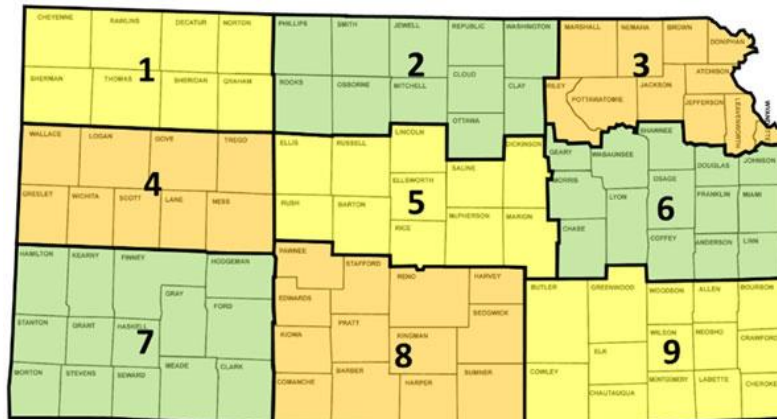
Source: Sittel, M. Kansas State University Agronomy eUpdates.

Table 1.1. Kansas Precipitation by Division (Sittel)

Division	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Northwest	0.42	0.56	1.05	2.07	3.22	2.91	3.53	3.10	1.68	1.67	0.73	0.61	21.58
North Central	0.68	0.87	1.56	2.49	4.37	3.86	4.31	3.60	2.55	2.05	1.22	1.00	28.56
Northeast	0.84	1.24	2.18	3.56	5.06	4.99	4.57	4.31	3.44	2.82	1.78	1.41	36.20
West Central	0.41	0.59	1.09	1.83	2.91	2.86	3.40	3.03	1.60	1.56	0.67	0.63	20.58
Central	0.72	1.02	1.78	2.62	4.67	3.99	4.07	3.83	2.56	2.15	1.20	1.08	29.68
East Central	0.96	1.45	2.35	3.79	5.33	5.03	4.26	4.23	3.68	3.02	2.01	1.50	37.62
Southwest	0.50	0.47	1.18	1.68	2.54	3.12	3.07	2.87	1.41	1.75	0.60	0.78	19.99
South Central	0.80	1.10	2.11	2.70	4.62	4.49	3.68	3.65	2.43	2.57	1.30	1.15	30.60
Southeast	1.28	1.65	2.83	4.26	6.20	5.54	4.28	4.02	4.06	3.60	2.39	1.87	41.96
STATE	0.78	1.07	1.90	2.92	4.51	4.25	3.95	3.69	2.75	2.47	1.42	1.19	30.91
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR

Source: Sittel, M. Kansas State University Agronomy eUpdates.

Table 1.2. Kansas 7-Day Max Precipitation by Division (Sittel)



Division	7-DAY MAX	DATE
Northwest	0.88	31-May
North Central	1.08	23-May
Northeast	1.22	9-Jun
West Central	0.85	2-Aug
Central	1.15	22-May
East Central	1.29	7-Jun
Southwest	0.78	6-Aug
South Central	1.14	6-Jun
Southeast	1.48	13-May

Source: Sittel, M. Kansas State University Agronomy eUpdates.

As the data in table 1.1. showcases, the Southwest Division has the lowest annual rainfall in the state of Kansas at 19.99 inches. This division's rainfall is also just at the minimum sourced inches of water use range for corn. Granted, there are drought-resilient corn varieties that can still be productive, with less annual precipitation, just with lower yields, and they are in place in this region. However, irrigation provides guaranteed inches of water for optimal growth and can nearly double yields depending on the timing of rains and soil types. This is an enticing incentive for producers with access to irrigation. Overall, irrigation results in significantly more bushels of corn being harvested to help meet the demand for feed in the region. Table 1.3. highlights what percentage of irrigated corn acres in the southwest region make up the total amount of irrigated corn acres in Kansas.

Table 1.3. State and Southwest Region Irrigated Corn Acres Harvested (USDA, NASS)

Irrigated Corn Acres Harvested			
Year	Kansas Census Irrigated Corn Acres Harvested	SW Region Census Irrigated Corn Acres Harvested	SW Region as a Percentage of Kansas Total
2022	1,181,420	639,072	54.09%
2017	1,339,530	742,948	55.46%
2012	1,414,014	760,358	53.77%
2007	1,509,702	849,645	56.28%
2002	1,346,807	799,563	59.37%
1997	1,454,245	868,843	59.75%

Source: USDA NASS

As table 1.3. suggests, consistently over half of all irrigated corn acres in the state are in the Southwest Region. It is interesting to note that in the 2022 Census, acres for both Kansas as a whole and the Southwest were notably less than earlier years. Additionally, the percentage of total irrigated corn acres in the Southwest used to be nearly 60% of the total for the state, and as

of 2022 was less than 55%. This data likely confirms the scarcity and decreasing available groundwater in the Ogallala Aquifer, which is a growing concern for the region and for several states with this resource. Table 1.4. illustrates irrigated corn acres harvested in the region compared to total corn acres harvested for the region. This shows that a majority of corn acres in this region are consistently derived from irrigated acres, reinforcing its significance and the importance of the Ogallala Aquifer for the region. It also shows that corn acres as a total and irrigated fluctuate throughout the years; however, the last two years hint at a lower percentage of irrigated corn acres to total corn acres, also supporting that total irrigated acres may be decreasing overall due to water constraints. The total corn acres harvested utilizes the sum of county-level survey data in the region, and for any missing counties without a value, it is replaced with the Census value in that given year.

Table 1.4. Southwest Kansas Total Corn Acres Harvested Compared to Irrigated Acres Harvested (USDA, NASS)

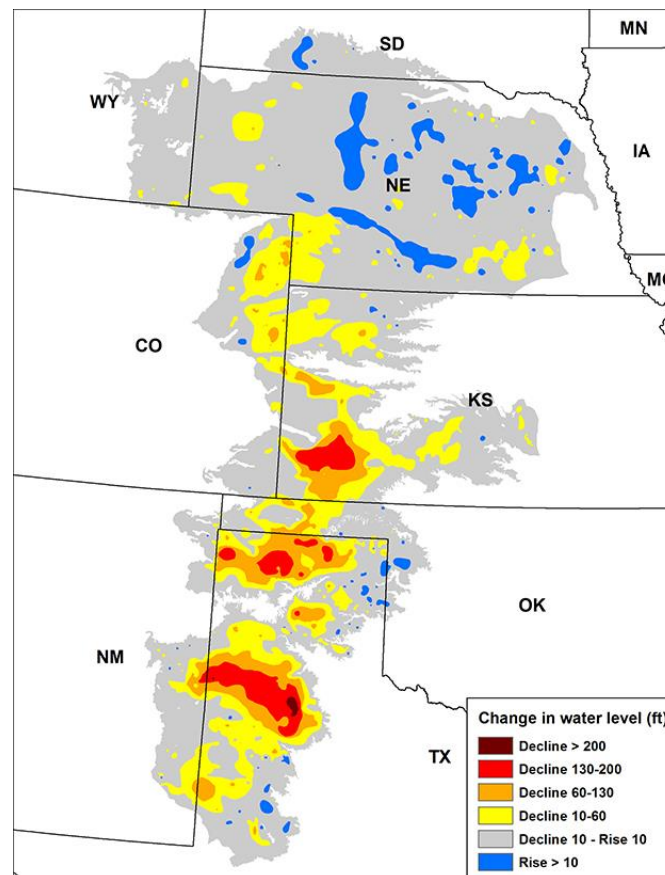
SW Region Corn Acres Harvested and Irrigated Corn Acres Harvested			
Year	SW Region Total Corn Acres Harvested	SW Region Census Irrigated Corn Acres Harvested	Percentage of Irrigated to Total
2022	1,021,196	639,072	62.58%
2017	1,359,238	742,948	54.66%
2012	935,097	760,358	81.31%
2007	1,127,397	849,645	75.36%
2002	886,100	799,563	90.23%
1997	1,018,800	868,843	85.28%

Source: USDA NASS

The Ogallala Aquifer has a large impact on U.S agriculture. The aquifer is present in a total of 8 states spanning from South Dakota down to the Texas Panhandle. It covers approximately 122 million acres of land, and produces one-fifth of all corn, wheat, and cotton in

the U.S. Approximately just 14% of the land area of the aquifer are irrigated acres, however, this utilizes one-fourth of the nation's total water use in agriculture (Frazier, et al). The corn acres data discussed from tables 1.3. and 1.4. hinted at the aquifer's sustainability concerns; however, there is strong data that supports this stance.

Figure 1.6. Ogallala Aquifer Mapped and Changes From 1950s to 2013 (Frazier, et al)



Source: Frazier et al, Oklahoma State University Extension

In the area of the southern High Plains, including Texas, Oklahoma, and Kansas, recharge rates for the aquifer are far less than what is being extracted. This is not a surprise given the area's semi-arid climate with annual rainfall that is less than evaporation. Overall, very little precipitation ends up reaching the groundwater (Frazier, et al). For the State of Kansas, 90% of

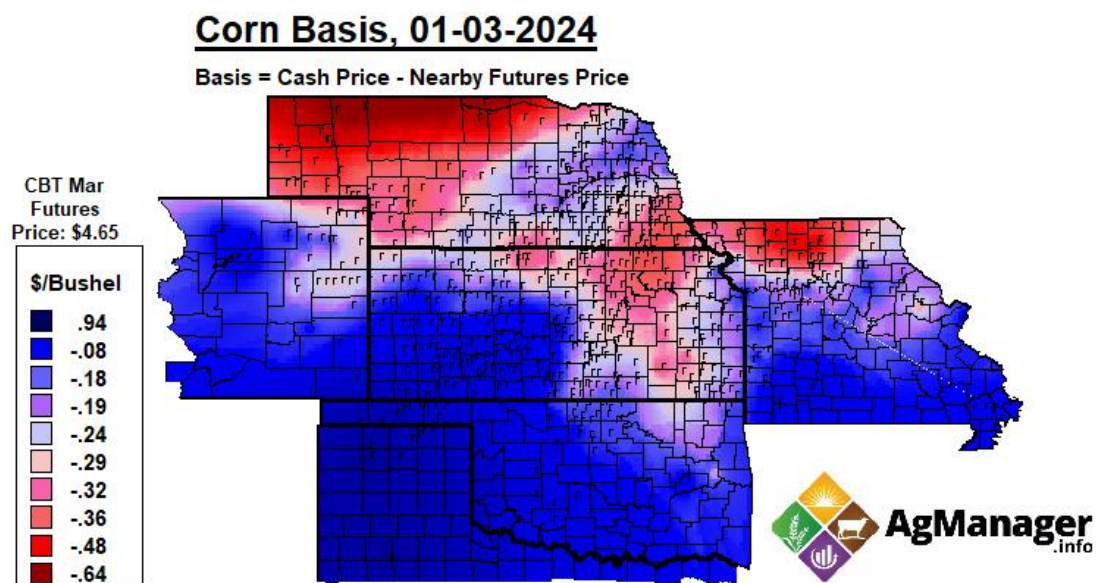
its total water use originates from the aquifer, and 80-85% of that use is for production agriculture. According to Brownie Wilson, a water data manager with the Kansas Geological Survey, more than one-fourth of the aquifer in Kansas is at a minimum threshold. Or below the capacity to pump 200 gallons a minute, which is a minimum rate for center pivot irrigation systems. Continuing, the current trend of extraction rates for Kansas is expected to result in nearly half of the aquifer being at a minimum threshold in another 50 years (Patterson). Additionally, according to data presented to the Kansas House Water Committee, in the southwest Kansas water management district, in the year 2024, the aquifer fell by an average of 1.52 feet compared to 1.43 feet the year prior (Kite).

The Ogallala Aquifer's long-term future in Southwest Kansas will be in question. Total Corn production may fall, and water use for even livestock may be a problem in the far future. However, likely total corn production will gradually cut back as time goes on to support sustainability and prolong the life of the aquifer. Improvements in water use efficiency, drought-tolerant crop varieties, and other improvements in technology, however, could even result in a smaller reduction of total corn acres than anticipated. Only time will tell, but if there is less corn, corn basis for the region will strengthen.

Most years, the southwest region does not quite produce enough corn to meet its strong demand, and it can be known as a corn-deficit area. With the help of irrigation, most immediate supply needs are met; however, the area will require supplemental corn to be hauled in from elsewhere around Kansas. Typically, the industry is known for the downward flow of corn from the North to the South. Even corn in Southwest Kansas may be shipped to meet livestock needs in Oklahoma or Texas, where supply has a greater scarcity. Moreover, corn silage is also in high demand in the area for its use in feed rations, and dairies, especially, are heavy users of silage. A

significant portion of corn in the area is chopped for silage, which results in more corn having to be transported in from elsewhere. In drought years, often a substantial amount of corn will be transported in from areas of the corn belt when basis levels in Southwest Kansas are high enough for transportation to be economical (Moore). On average, the corn basis in this region will be higher than the basis in the corn belt because of the lower comparative supply and high demand. Figure 1.6. illustrates how basis levels compare regionally in the Southwest compared to the Northeast.

Figure 1.7. Corn Basis Heat Map Example (Llewelyn)



Source: Llewelyn, R. Kansas State Extension AgManager

1.2 Motivation

The changing factors discussed that are taking place in the region will likely have a measurable impact on corn basis. Demand for corn is rising, and local supply may be shrinking

in the future. The new feedlot that will feed 88,000 cattle will be substantial. With the expansion in the dairy industry, and if the area does not already have enough milk cows to meet the demand for the new Hilmar Cheese facility, an increase of 110,000 dairy cows for the area will have an even larger impact. This would be a greater than 50% growth in the region for total dairy cattle inventory in a very short time frame. Both of these changes will require more corn for feed, and additionally, as mentioned, dairy cows require a significant amount of corn silage for feed. If there is an increase of 110,000 dairy cows, this may convert enough corn acres to be chopped for silage such that total corn supply for grain will noticeably decrease.

An example highlighted by the University of Tennessee's Ag Extension Service was that a 1,300 lbs. dairy cow producing 100 lbs. of milk per day would require approximately 54 lbs. of total Dry Matter (DM) for feed (Bernard & Montgomery, 1997). According to a dairy production expert Jean-Philippe Laroche, corn silage for feed can vary between 25% and 75% of total forage DM. Corn silage itself, on average, after harvest is assumed to be 35% DM and 65% moisture (Hendrix). Additionally, assuming corn silage acres in Southwest Kansas would primarily originate from irrigated acres, a yield between 20 - 25 tons an acre can be assumed (Amaral-Phillips, et al). Putting these assumptions altogether a range of silage acres can be calculated for an assumed addition of 110,000 dairy cows to the region and an average yield of 22.5 tons per acre for silage production.

$$\frac{54 \text{ lbs. per cow per day}}{1 \text{ Total DM}} * \frac{0.25 \text{ Total DM}}{1 \text{ lbs. Corn Silage per cow per day}} * \frac{1 \text{ lbs. feed per cow per day}}{0.35 \text{ lbs. Corn Silage per cow per day}} * \frac{365 \text{ days}}{1 \text{ year}} *$$

$$\frac{1 \text{ tons feed per cow per year}}{2000 \text{ lbs.}} * \frac{1 \text{ acre silage}}{22.5 \text{ tons per acre}} * \frac{110,000 \text{ dairy cows}}{\text{Total acres of Silage}} = 34,414 \text{ Corn Silage Acres}$$

$$\frac{54 \text{ lbs. per cow per day}}{1 \text{ Total DM}} * \frac{0.75 \text{ Total DM}}{1 \text{ lbs. Corn Silage per cow per day}} * \frac{1 \text{ lbs. feed per cow per day}}{0.35 \text{ lbs. Corn Silage per cow per day}} * \frac{365 \text{ days}}{1 \text{ year}} *$$

$$\frac{1 \text{ tons feed per cow per year}}{2000 \text{ lbs.}} * \frac{1 \text{ acre silage}}{22.5 \text{ tons per acre}} * \frac{110,000 \text{ dairy cows}}{\text{Total acres of Silage}} = 103,243 \text{ Corn Silage acres}$$

These calculations illustrate that there could be a significant impact on corn acres for silage production. There are a lot of moving parts such as actual total increase in dairy cows for the region, the average weight of the dairy cows, milk production goals, and, depending on specific operations what their actual percentage of total forage DM is corn silage. Nevertheless, there will be impacts from the new livestock demand in the area that will likely influence corn basis. Moreover, if corn production also decreases in the coming years due to water constraints, that will have long-term impacts as well. The motivation of this study is to estimate these main economic factors' effect on corn basis in the southwest Kansas region, to develop corn basis forecasting models, and to scenario test potential outcomes. There is well established literature in corn basis forecasting; however, this study seeks to be unique by only examining the southwest Kansas region, incorporate local economic factors, quantify how livestock can affect corn basis in a strong livestock region, and predict potential outcomes for potential future changes in the region.

1.3 Literature Review

Tomek (1996) described basis as the difference between cash and futures price for a specific commodity, with determined specifications, and for a specific delivery location. Jiang and Hayenga (1997) and others have addressed the importance of forecasting grain basis. Producers, grain merchandisers, and processors all must have familiarity with their local basis and accurately forecast basis levels to optimally make business decisions. Inaccurate basis projections can lead to ineffective hedging. Hedging strategies are universal in the grain industry and utilized by producers as well. Hedging is often taking an appropriate futures position while simultaneously in a long or short position in physical grain. There have been numerous grain basis forecasting studies utilizing historical moving averages, econometric modeling, and other methods. The following will address well-known studies and what this study adds to current literature.

Dhuyvetter and Kastens in 1998 developed basis forecasting models specific to Kansas that avoided the use of econometric models and focused on simpler approaches. They highlighted that previous literature supports historical average methods to have strong accuracy. The goal of their research was to provide valuable information to producers and showcase data readily available to them, to provide insights for basis forecasting. They constructed three different types of models. Models that relied on historical averages, models including current market information such as futures price spreads and deviations compared to a historical average, and a naïve forecast utilizing lagged basis. These were all compared by exhibiting their absolute errors in forecasting to measure their accuracy. Their results concluded that a 4-year average was optimal for forecasting wheat basis, while the 5-7-year average worked better for corn, sorghum, and soybean basis. Other notable findings include that incorporating current market information

can strengthen short-term projections. However, for longer term horizons such as 8 to 12 weeks, historical averages proved to be best. Additionally, they noted forecast errors were highest for all the crops during critical production periods such as planting, critical growth stages, and when weather was the most variable. These time periods are when the risk of forecasting can be the highest.

Jinag and Hayenga (1997) employed several different complex strategies to forecast corn and soybean basis in a handful of different markets dispersed around the U.S. This included a naïve model of a 3-year average to act as a benchmark method. A 3-year average model supplemented with current market information, which was USDA supply and export estimates. Econometric models with independent variables such as storage costs, transportation rates, and regional supply and demand variables. Advanced time series models such as a seasonal ARIMA model and a State Space model. The seasonal ARIMA is described as a statistical analysis that examines and leverages patterns with a single data set to forecast future values. While the State Space model is a statistical method that computes optimal estimates for a multivariate time series. Lastly artificial neural network models were also employed. They utilize an algorithm to map non-linear and non-random patterns that could be hidden in a series. It was noted that this could be an adequate strategy since interactions among dispersed markets in the country and the relationship between cash and futures markets can be nonlinear in nature. The results concluded that the 3-year average model supplemented with current market information and the seasonal ARIMA resulted in the highest accuracy when out of sample. However, improvement was not substantial in comparison to the simple 3-year average, which may suggest the extra effort to employ such models is not worthwhile. For corn basis specifically the artificial neural network models' ability to forecast 1-12 months ahead was determined superior. However, the

econometric models and 3-year average with current information were better for the shorter-term forecasts, or less than 4 months.

Taylor, Dhuyvetter, and Kastens in 2006 expanded upon Dhuyvetter and Kastens' study in 1998. This study updated the data set to include more recent data, revisited determining the optimal historical average years to forecast, changed the forecasts time frame to just harvest time and 24 weeks after harvest, and lastly changed the historical average models that incorporated current market information. Their new current market information was defined as the deviation of current basis from historical levels on the date the forecast was made. The results of their new findings concluded that structural change had likely occurred in the grains market and that the previous longer time periods to explain basis variation no longer yield the most accurate results. Wheat was the exception that a historical 5-year average was the best predictor for basis for the harvest time forecast. However, corn, soybeans, and sorghum were all predicted the most accurately with just the 1-year historical average for the harvest time forecast. Incorporating the models with current market information yielded the best results for the post-harvest period. However, it was a poor predictor for pre-harvest forecasts. Which makes sense, because current information before harvest is based on old crop information which is not helpful for projecting the new crop. Compared to after harvest the information is more prevalent and there is less uncertainty.

Thompson et al. (2019) built upon Taylor, Dhuyvetter, and Kastens 2006 and other prior literature with a similar approach. Thompson et al 2019 examined multiple years to determine the most accurate historical average for predicting basis for corn and soybeans, explored basis forecasting for all months out of the crop marketing year, explored models incorporating current information as well as naïve forecasts, and lastly incorporated a large geographic region covering

grain elevators across the eastern corn belt including Illinois, Indiana, Michigan, and Ohio. The goal of this study was to explore practical basis forecasting methods for this area and over a time frame succeeding in the start of the ethanol boom. This was to examine if the results have changed in recent years since prior established literature. The results of the study included that during the harvest months of October through November historical moving averages such as 4 to 5 years for corn and 1 to 2 years for soybeans showed to be the most accurate. Even though prior studies suggested a 1-year average proved to be the most accurate Thompson et al explained this is likely due to the structural change of the ethanol boom ‘leveling out’ and becoming consistent. Which would permit longer historic averages to provide higher accuracy again. Other findings from the study included that models incorporating current information were best for short term horizons post-harvest, however their ability to forecast quickly deteriorated with periods over 12 weeks. Additionally, all forecasting methods for both corn and soybeans sharply decline from the month of April until August. Naïve forecasts were determined as the best predictor during this time frame; however, it would still carry a high error term. Lastly across the board the mean absolute errors were higher in this study compared to the previous studies and the authors contributed it to higher volatility in the markets compared to the past and likely the changes brought by the ethanol boom.

Wu et al in 2017 took a different approach to basis forecasting and widely focused on advance econometric modeling incorporating local supply and demand factors and modeled specifically for the region of Ontario Canada. Their goal was to exhibit how the growth in the ethanol industry for the region had impacted corn basis. They examined 7 regional elevators from 2006 to 2013 and used independent variables such as nearby ethanol capacity, livestock corn consumption, cost of grain storage, and corn production. The models employed were Vector

Error Correction Models (VECM), Panel VECM, and a conceptual spatial model to illustrate the change in basis if the region became a net importer of corn instead of exporter. The VECMs were employed to provide a more accurate model and to quantify both short run and long run impacts. They were also able to provide direction of casualty, which confirmed for the market in Ontario that ethanol capacity drives basis, and not the opposite. Meaning basis levels do not attract the growth and establishment of ethanol plants, but ethanol plants are independent and they drive basis. Panel VECMs also permitted the analysis of the aggregate impact on basis across the entire region using maximum likelihood methods. Overall results of the study concluded that after an increase of 100 million liters in ethanol capacity in a 2-year period, basis strengthened among locations varying between \$0.30 and \$0.60 per bushel and the aggregate level strengthened by \$0.28. They also noted that surprisingly however, overall corn basis decreased at the end of the time series after the established expansion in ethanol plants. They explained this however to be the fact because corn production in the area increased by 50% and the new supply actually surpassed the new demand. Demand for feed for livestock also decreased during this time frame as well which likely contributed to the result. Lastly, they did find statistical significance in livestock demand, storage costs, and transportation in explaining corn basis however it did vary between locations

Lastly, Welch et al (2009) took a similar econometric approach when forecasting corn basis in a identified “Texas Triangle Area” in the Texas Panhandle. They implemented a simple (OLS) Ordinary Least Squares linear regression model and incorporated independent variables such as a lagged basis, local cash price, December futures price, projected ending stocks, and a transportation index. They then compared this economic model’s accuracy in forecasting basis to a simple 3-year average model. Similar to the previously discussed results, they concluded that

likely due to the ethanol boom, structural change has occurred and the moving average techniques for forecasting are less accurate. At least in the case of the Texas Triangle Region. They noted that especially for a region like this, that is a corn deficit area, the competition to originate corn has increased which has contributed to a less reliable naïve forecast. They illustrated an example of a producer pricing based on predicting basis with the 3-year moving average and using the economic model, which resulted in roughly a \$0.10 difference more favorable for the economic model. Lastly the independent variables of the economic model were all statistically significant, explaining 67% of the variation in corn basis for this area.

The culmination of this established literature supports a variety of different strategies to forecast basis. Some focused on simpler strategies while others employed advanced complex models. Several of the studies agreed that structural changes have occurred in the U.S grain markets and depending on geography simple average naïve forecasts may not produce the strong results it once did. Moreover, consistent across the literature was the difficulty to forecast basis in the summer months leading up to harvest and during critical growth stages. Intuitively this makes sense because uncertainty about the new crop can be at its highest and crop prices are likely the most volatile. Naïve forecasts and methods incorporating current market information were likely to perform the best post-harvest and for shorter time horizons, while multiple year average methods were better for longer time horizons. Although moving average basis models could provide decent accuracy for large scale regions, smaller regions exhibited the ability to be improved upon with more complex models. Given the literature's results, econometric models can provide a happy medium for a method to forecast basis. They incorporate other data sources to increase accuracy while not overcomplicating the process and can utilize data that does not require immense effort to acquire. Additionally, the literature supports that incorporating local

supply and demand factors for region-based forecasting can provide greater accuracy. Lastly, then impacts on corn basis can be measured when using econometric models.

This study similar to Wu et al (2017) and Welch et al, (2009) will incorporate local supply and demand variables to provide higher accuracy for forecasting. It will examine unique factors such as a strong and growing livestock industry and the scope of this study will answer slightly different questions than existing literature proposes. This study will be forward looking and as discussed, changes in the southwest Kansas region are anticipated. Because of this, the outcomes on corn basis for the region will be measured. Past literature, for example, has examined ethanol plants going live in a region then measuring their impact afterwards. This study will measure the impact the growing livestock industry could have on corn basis in the future.

Chapter 2 - Methodology

To estimate corn basis in Southwest Kansas, similarly to established literature, ordinary least squared (OLS) linear regression models were used. Standard variables from literature as well as the discussed local supply and demand factors were also employed as independent variables to explain the variation in basis. This specifically includes corn futures prices, cattle inventory, corn acres planted, corn silage acres harvested, diesel prices, and monthly dummy variables. The intent is to use model estimates to project potential impacts of changing independent variables on future corn basis levels in the region.

Since basis is equal to cash minus futures prices, corn basis captures local supply and demand effects illustrated through cash prices relative to futures. While futures prices, part of the basis calculation, capture all regional or global effects on U.S corn prices, which is expected to have an impact. As discussed with the strong livestock industry in Southwest Kansas, cattle inventory is expected to have a strong effect on local corn basis. Corn acres planted will be used as a proxy to represent total corn production in the region. Acreage is used instead of production to enable changing acreage directly in model projections. In addition, corn silage acres will also be examined because of its assumed growing presence in the region and its potential effect on basis. Diesel prices will be used as a proxy for grain transportation costs, which directly impacts basis. Especially for an area like southwest Kansas which imports corn. Lastly, monthly dummy variables capture seasonality since corn supply and demand are seasonal.

Two types of models were estimated for this study. The first type of models is to be interpreted as regional for Southwest Kansas. One of them uses an average basis for the entire region with regional level independent variables. Then the others examine specific grain elevators selected to represent Southwest Kansas, still using regional independent variables. The

second type of models drill down to examine specific grain elevators while using independent variables derived from the respective counties they reside in. The goal of these models is to provide the option for more localized analysis. Below are these types of models illustrated in mathematical notation with definitions. All regressions were estimated in R Studio and predictions, and other analyses were performed in Excel.

Southwest Kansas Regional Models

(1) Average Corn Basis for Southwest Kansas:

$$\begin{aligned} AvgCornBasis = & \beta_0 + \beta_1 NearbyCornFutures + \beta_2 SWTotalCattleInventory + \\ & \beta_3 SWPlantedCornAcres + \beta_4 SWCornSilageAcres + \beta_5 DieselPrices + \beta_6 JanDummy + \\ & \beta_7 FebDummy + \beta_8 MarDummy + \beta_9 AprDummy + \beta_{10} MayDummy + \beta_{11} JunDummy + \\ & \beta_{12} JulDummy + \beta_{13} AugDummy + \beta_{14} SepDummy + \beta_{15} OctDummy + \beta_{16} NovDummy + \mathcal{E} \end{aligned}$$

(2) Southwest Kansas Representative Grain Elevators:

{Including corn basis from, Garden City Coop (Garden City), Alliance Ag (Dodge City), ADM (Montezuma), Scott Coop (Scott City), and Equity Exchange (Liberal)}

$$\begin{aligned} CornBasis = & \beta_0 + \beta_1 NearbyCornFutures + \beta_2 SWTotalCattleInventory + \\ & \beta_3 SWPlantedCornAcres + \beta_4 SWCornSilageAcres + \beta_5 DieselPrices + \beta_6 JanDummy + \\ & \beta_7 FebDummy + \beta_8 MarDummy + \beta_9 AprDummy + \beta_{10} MayDummy + \beta_{11} JunDummy + \\ & \beta_{12} JulDummy + \beta_{13} AugDummy + \beta_{14} SepDummy + \beta_{15} OctDummy + \beta_{16} NovDummy + \mathcal{E} \end{aligned}$$

Models with County Level Independent Variables:

(1) *Individual Grain Elevators:*

{Including corn basis from, CHS (Tribune), Scott Coop (Scott City), DE Bondurant Grain (Ness City), Skyland (Syracuse), Garden City Coop (Garden City), Pawnee County Coop (Larned), ADM (Montezuma), Alliance Ag (Dodge City), Offerle Coop (Bucklin), Elkhart Coop (Rolla), Equity Exchange (Liberal), and Meade Coop (Meade)}

$$\begin{aligned} \text{CornBasis} = & \beta_0 + \beta_1 \text{NearbyCornFutures} + \beta_2 \text{CountyCattleInventory} + \\ & \beta_3 \text{CountyPlantedCornAcres} + \beta_4 \text{CountyCornSilageAcres} + \beta_5 \text{DieselPrices} + \beta_6 \text{JanDummy} + \\ & \beta_7 \text{FebDummy} + \beta_8 \text{MarDummy} + \beta_9 \text{AprDummy} + \beta_{10} \text{MayDummy} + \beta_{11} \text{JunDummy} + \\ & \beta_{12} \text{JulDummy} + \beta_{13} \text{AugDummy} + \beta_{14} \text{SepDummy} + \beta_{15} \text{OctDummy} + \beta_{16} \text{NovDummy} + \varepsilon \end{aligned}$$

- *AvgCornBasis* is the average of all elevators' monthly corn basis examined in the region.
- *CornBasis* is the monthly average of corn basis bids from the specific elevator exhibited.
- *NearbyCornFutures* is the monthly nearby corn futures price.
- *SWTotalCattleInventory* is the January 1st total cattle inventory, including calves, for the entire region scaled to a monthly basis.
- *SWPlantedCornAcres* is the total annual corn acres planted in the region scaled to a monthly basis.
- *SWCornSilageAcres* is the total annual corn silage acres harvested in the region scaled to a monthly basis.
- *CountyCattleInventory* is the cattle inventory, including calves, in the county the specific grain elevator examined resides in, scaled to a monthly basis.

- *CountyPlantedAcres* is the annual corn acres planted, in the county the specific grain elevator examined resides in, scaled to a monthly basis.
- *CountyCornSilageAcres* is the annual corn silage acres harvested, in the county the specific grain elevator examined resides in, scaled to a monthly basis.
- *DieselPrices* is the monthly Midwest No 2 Diesel Ultra Low Sulfur retail prices.
- *Jan-NovDummy* are monthly dummy variables from the month of January to November.

Table 2.1. Expected Signs of Coefficients

Expected Signs of Coefficients	
Independent Variables	Signs
Nearby Corn Futures	+
Total Cattle Inventory	+
Planted Corn Acres	-
Corn Silage Acres	+
Diesel Prices	+
January Dummy	+
February Dummy	+
March Dummy	+
April Dummy	+
May Dummy	+
June Dummy	+
July Dummy	+
August Dummy	+
September Dummy	-
October Dummy	-
November Dummy	-

Table 2.1. showcases the anticipated sign for each variable. It is expected the signs will remain the same throughout each model. Nearby Corn Futures, all else equal, is expected to be positive since Southwest Kansas has a strong demand for corn and as overall corn price

increases, the convenience yield of having corn available when needed to feed livestock increases locally strengthening basis. This is because if there is a high demand for corn in the U.S as a whole, indicated by nearby corn futures prices being higher, then likely there is a low supply of corn overall, increasing convenience yield (the value of having corn in inventory when needed by a livestock producer or ethanol plant for example). Which would mean greater difficulty for sourcing corn for feed in Southwest Kansas. Thus, resulting in a positive relationship, increasing basis in this region when nearby corn futures strengthen. Total cattle inventory is also expected to be positive because as livestock numbers increase, demand for corn in the region rises. The greater number of cattle, the greater amount of corn required for feed which would result in a strengthening basis. Planted corn acres on the other hand are expected to be negative, maintaining an inverse relationship. Since planted corn acres represents corn supply in these models and is the direct source of corn, simply more corn acres would result in a greater amount of corn and a weaker basis because of the abundance. Corn silage acres are expected to be positive. This is because, since there has been a growth of silage for feed, it is hypothesized that enough acres of corn, for grain, have been converted to silage that this lowers total grain supply and thus corn basis will increase.

The diesel prices coefficient is also expected to be positive in large part because again, Southwest Kansas is an importer of corn from other regions in the U.S. When diesel prices rise, regardless this region needs the corn for feed. So, basis is expected to strengthen in proportion to the rise in transportation costs, to ensure the demand for corn is met. Lastly, for the monthly dummy variables it is expected January through August will be positive, while September through November will be negative. December is the month that is dropped for this analysis, so this is a comparison of basis in all months compared to December's. It is expected that after

December corn basis is likely to strengthen gradually in the coming months when it will hit a peak in the summer, likely around July, then in August it may start to drop since harvest is approaching. Then in September, a month where harvest can start, basis is likely weaker than in December showcasing a negative sign. Then October and November is expected to certainly have a negative sign since they are harvest months.

Chapter 3 - Data

This chapter will describe the nature of the data behind each variable, where it was sourced, the decision process, transformations, and considerations. Not all the data sets were complete and strategies in each case were implemented to counteract these issues. In addition, this section will also provide analysis to some of the variables' data to provide further background information for the region which is found to be insightful to the study. All OLS basis models were estimated using monthly average basis as the dependent variable with similar monthly averages or repeated annual values for the independent variables depending on available data. First table 3.1. illustrates the summary statistics of the regional model variables.

Table 3.1. Regional Model's Summary Statistics Monthly Between 2015 - 2024

Summary Statistics						
Variable	Mean	Median	Std. Dev.	Minimum	Maximum	Observations
Average Corn Basis \$/bu.	0.137	0.093	0.444	-0.558	1.644	168
Nearby Corn Futures \$/bu.	4.866	4.289	1.374	3.155	8.135	168
Total Cattle Inventory (1M)	2.657	2.685	0.128	2.448	2.812	168
Planted Corn Acres (1M)	1.266	1.249	0.221	0.935	1.791	168
Corn Silage Acres (100k)	0.918	0.924	0.341	0.516	1.748	168
Diesel Prices \$/gal.	3.382	3.484	0.769	1.927	5.662	168

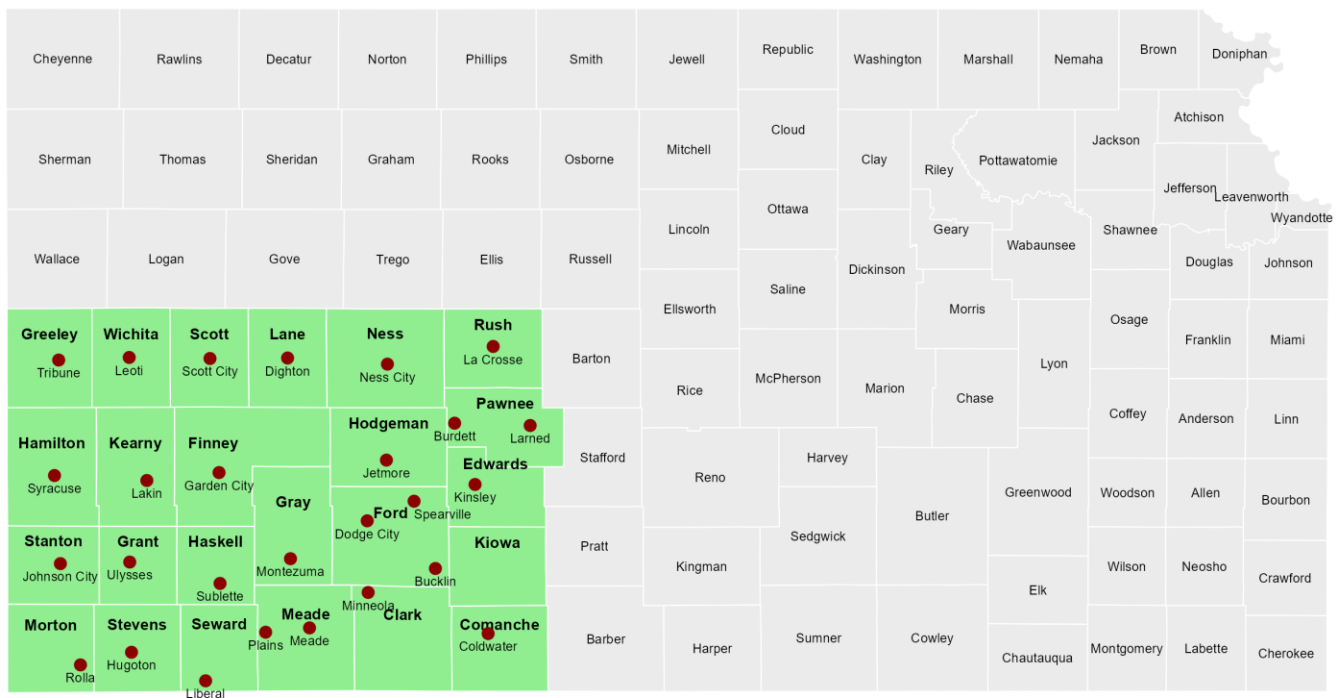
Sources: Geograin, Barchart, USDA NASS, EIA

3.1 Corn Basis

The corn basis data was a case where the data set for every elevator in the study was not perfectly complete, and some assumptions had to be made. The very nature of grain basis data can make it rare to find full data for a time series of over numerous years. The data was sourced from Geograin, a cash grain data collection agency. Daily corn basis for 30 different grain elevators was collected from towns in Southwest Kansas. The beginning of the data set for each

location varied, with most starting in the late 1990s to early 2000s all ending at the present time the data was pulled in August of 2025. For the initial analysis, a time frame of 2011 to the present was selected because multiple elevators had more erratic and spotty data just before 2011. Yet an ample sample size was still the goal to maintain. An initial analysis of the data of all the grain elevators was performed to provide better insights into grain pricing in the area. It was also done to provide a consistent strategy to slim down the 30 grain elevators, to ensure a prediction of basis for ones that would only provide the most value. Figure 3.1. illustrates where the towns that the 30 grain elevators are located in are, for the analysis.

Figure 3.1. The Southwest Kansas Towns Where the 30 Grain Elevators are Located



Sources: TIGER/Line via tigris

The transformations for all the data involved scaling from daily to weekly data, then from weekly to monthly data. Monthly data was determined to be the most appropriate since this study is seeking to explain the change in basis behavior over time and not necessarily day to day or week to week changes. The daily to weekly data calculation was designed to seek simplicity for the monthly calculation by providing 4 weeks per month, however the goal was to still incorporate as many values as possible for the averages. The weekly calculation was the simple average of daily values in a week and if there were 5 weeks in the month the 5th and 4th week would be averaged together. In addition, if the first week of the month had only 3 calendar weekdays days or less, such as Wednesday-Friday, then instead those days would be averaged with the second calendar week and that would be the new first week. Then if there were still 5 weeks total after this was performed, which is a rare occurrence, then the 4th and 5th weeks would be averaged together too. More often, with how the calendar falls, if there are 3 weekdays or less in the first week of the month, then the 5th week has more weekdays than the first or even has a full week of weekdays. So, in this case the first and second week averaged together provides a more representative value for a week 1 and the 5th week alone is more representative for a week 4.

This calculation was made and designed to be scaled to monthly data by averaging 4 weeks per month, because several grain elevators would have weeks and months of missing data. By employing this strategy, it was easier to create proxies to fill in the missing weeks by following consistent assumptions and rules. There wasn't a single grain elevator that had enough daily data to have an average for every single week during the time frame. However, most would just be 2-8 weeks in a row missing, scattered randomly throughout the years. If there were anywhere from 1-7 values missing in a row and there were several weeks before and after those

missing values that all had the same basis, then the missing weeks would also be filled with that same basis value. If only one week was missing, then the average of the previous week and the next available week were taken, and the same for if it were 2-7 weeks in a row that were missing. If it were 8 or more weeks in a row missing or, 2 months or greater, then the elevator with the missing values would be regressed on the nearest immediate grain elevator, that provided the highest R squared. Then the coefficient value and constant were used to predict the missing values. This was done for 19 different grain elevators, with an average of 2-3 stretches of 8 or more missing values for each. 17 of these stretches of missing values were over 15 weeks, 5 of those were over, 25 weeks, 1 was just over 50 weeks, and 1 was 75 weeks in a row of missing values. All R squares were above 0.9 for predictions except for the lowest at 0.83.

Figure 3.2. below illustrates and labels where each grain elevator is and the town it resides in for the initial analysis. Each grain elevator has a unique color that identifies their ownership. Note some towns have two elevators under different ownership, which explains the few towns with two colored dots right next to each other.

Figure 3.2. Southwest Kansas Grain Elevator Locations and Ownership



Sources: TIGER/Line via tigris

The process of this initial analysis of all the grain elevators also helped determine the grain companies with a larger geographic footprint and likely the ones that move the most volume of grain. The elevators that move the most volume of grain can be interpreted to have an accurate and more widely used basis compared to others. For example, figure 3.2. suggests Garden City Coop, Alliance Grain, Skyland Grain, and ADM are the companies with the most grain elevators in the region. To determine the best course of action of slimming down the 30 grain elevators for the study, the use of correlations for the basis data among all locations was used. The basis data was kept in weekly form for the correlation calculations to still provide granularity and a larger series. Not surprisingly, basis values for grain elevators nearest to each other were generally most highly correlated. Some grain elevators that were under the same ownership and were close to each other would often nearly have identical basis values. Then others that were farther apart under the same ownership would still be highly correlated but have

different values. This could indicate that when the basis values move in the same direction, their difference is likely only in transportation cost. Table 3.2. is a correlation matrix of the basis data for the 30 grain elevators. Note the earliest available data for DE Bondurant Grain in Ness City was only from 2015 and onwards. Moreover, Offerle Coop in Spearville doesn't have data that starts until the second week in December of 2013. For both of these locations any grain elevator correlated against them and any locations they were correlated against only started on their respective available data dates. The darker the red color in table 3.2. on highlighted correlation values means the more highly correlated the two grain elevators are. The darker blue color indicates the least correlation between two grain elevators.

Table 3.2. Pearson Correlation Table of All 30 Grain Elevators

Grain Locations	CHS (Tribune)	ADM (Leoti)	Scott Coop (Scott City)	Garden City Coop (Dighton)	DE Bondurant Grain (Ness City)	Midland Marketing (LaCrosse)	Skyland Grain (Syracuse)	Garden City Coop (Lakin)	Garden City Coop (Garden City)	Alliance Ag (Jetmore)	Golden Valley (Burdett)	Golden Valley (Larned)	Pawnee County Coop (Larned)	Alliance Ag (Dodge City)	Alliance Ag (Spearville)	Offerle Coop (Spearville)	Alliance Ag (Kinsley)	Skyland Grain (Johnson City)	Garden City Coop (Ulysses)	Skyland Grain (Sublette)	ADM (Montezuma)	Alliance Ag (Minneapolis)	Offerle Coop (Bucklin)	Elkart Coop (Rolla)	Skyland Grain (Rolla)	Equity Exchange (Hugoton)	Equity Exchange (Liberal)	ADM (Plains)	Meade Coop (Meade)	Alliance Ag (Coldwater)
CHS (Tribune)	1.000	0.972	0.974	0.973	0.972	0.871	0.963	0.974	0.973	0.962	0.960	0.960	0.941	0.967	0.968	0.967	0.964	0.966	0.967	0.963	0.968	0.968	0.962	0.966	0.968	0.967	0.966	0.971	0.966	0.959
ADM (Leoti)	0.972	1.000	0.990	0.985	0.984	0.871	0.982	0.985	0.983	0.975	0.971	0.971	0.953	0.981	0.983	0.976	0.981	0.979	0.979	0.979	0.986	0.979	0.977	0.973	0.973	0.972	0.971	0.987	0.983	0.974
Scott Coop	0.974	0.990	1.000	0.989	0.978	0.862	0.984	0.987	0.984	0.973	0.974	0.975	0.948	0.975	0.976	0.971	0.977	0.979	0.980	0.976	0.977	0.975	0.974	0.971	0.973	0.973	0.973	0.981	0.977	0.966
Garden City Coop	0.973	0.985	0.989	1.000	0.981	0.869	0.976	0.990	0.993	0.972	0.970	0.971	0.943	0.976	0.977	0.967	0.977	0.978	0.990	0.977	0.981	0.976	0.971	0.976	0.976	0.975	0.975	0.984	0.974	0.968
DE Bondurant Grain	0.972	0.984	0.978	0.981	1.000	0.907	0.973	0.980	0.979	0.973	0.978	0.978	0.961	0.982	0.983	0.979	0.976	0.972	0.977	0.972	0.982	0.982	0.979	0.968	0.969	0.971	0.971	0.981	0.981	0.980
Midland Marketing	0.871	0.871	0.862	0.869	0.907	1.000	0.845	0.873	0.876	0.847	0.853	0.853	0.858	0.872	0.870	0.884	0.858	0.858	0.871	0.861	0.878	0.874	0.860	0.866	0.869	0.871	0.871	0.880	0.870	0.862
Skyland Grain	0.963	0.982	0.984	0.976	0.973	0.845	1.000	0.981	0.977	0.967	0.964	0.964	0.947	0.977	0.978	0.967	0.978	0.994	0.980	0.986	0.979	0.970	0.968	0.978	0.984	0.976	0.975	0.981	0.976	0.968
Garden City Coop	0.974	0.985	0.987	0.990	0.980	0.873	0.981	1.000	0.995	0.981	0.976	0.976	0.950	0.982	0.984	0.977	0.982	0.985	0.991	0.984	0.987	0.982	0.978	0.983	0.985	0.981	0.981	0.989	0.978	0.976
Garden City Coop	0.973	0.983	0.984	0.993	0.979	0.876	0.977	0.995	1.000	0.979	0.974	0.974	0.946	0.982	0.983	0.975	0.980	0.984	0.996	0.985	0.988	0.984	0.975	0.983	0.985	0.982	0.982	0.990	0.977	0.975
Alliance Ag	0.962	0.975	0.973	0.972	0.973	0.847	0.967	0.981	0.979	1.000	0.982	0.983	0.957	0.979	0.981	0.979	0.984	0.969	0.973	0.972	0.976	0.979	0.978	0.966	0.968	0.965	0.964	0.979	0.974	0.979
Golden Valley	0.960	0.971	0.974	0.970	0.978	0.853	0.964	0.976	0.974	0.982	1.000	1.000	0.970	0.967	0.969	0.982	0.972	0.965	0.970	0.962	0.968	0.973	0.980	0.964	0.965	0.964	0.963	0.971	0.975	0.969
Golden Valley	0.960	0.971	0.975	0.971	0.978	0.853	0.964	0.976	0.974	0.983	1.000	1.000	0.969	0.968	0.970	0.982	0.973	0.966	0.971	0.962	0.968	0.974	0.980	0.964	0.965	0.965	0.964	0.971	0.975	0.969
Pawnee County Coop	0.941	0.953	0.948	0.943	0.961	0.858	0.947	0.950	0.946	0.957	0.970	0.969	1.000	0.960	0.961	0.972	0.964	0.946	0.944	0.941	0.950	0.951	0.967	0.944	0.946	0.939	0.939	0.950	0.962	0.970
Alliance Ag	0.967	0.981	0.975	0.976	0.982	0.872	0.977	0.982	0.982	0.979	0.967	0.968	0.960	1.000	0.999	0.987	0.988	0.981	0.979	0.984	0.987	0.990	0.981	0.977	0.980	0.979	0.978	0.987	0.987	0.988
Alliance Ag	0.968	0.983	0.976	0.977	0.983	0.870	0.978	0.984	0.983	0.981	0.969	0.970	0.961	0.999	1.000	0.988	0.989	0.981	0.979	0.984	0.987	0.990	0.983	0.977	0.979	0.979	0.978	0.987	0.987	0.988
Offerle Coop	0.967	0.976	0.971	0.967	0.979	0.884	0.967	0.977	0.975	0.979	0.982	0.982	0.972	0.987	0.988	1.000	0.984	0.971	0.972	0.972	0.980	0.987	1.000	0.967	0.970	0.971	0.971	0.980	0.984	0.988
Alliance Ag	0.964	0.981	0.977	0.977	0.976	0.858	0.978	0.982	0.980	0.984	0.972	0.973	0.964	0.988	0.989	0.984	1.000	0.979	0.976	0.980	0.982	0.980	0.980	0.973	0.976	0.974	0.973	0.983	0.980	0.986
Skyland Grain	0.966	0.979	0.979	0.978	0.972	0.858	0.994	0.985	0.984	0.969	0.965	0.966	0.946	0.981	0.981	0.971	0.979	1.000	0.988	0.993	0.986	0.976	0.969	0.988	0.996	0.985	0.984	0.987	0.976	0.972
Garden City Coop	0.967	0.979	0.980	0.990	0.977	0.871	0.980	0.991	0.996	0.973	0.970	0.971	0.944	0.979	0.979	0.972	0.976	0.988	1.000	0.985	0.987	0.979	0.972	0.984	0.988	0.983	0.982	0.988	0.974	0.970
Skyland Grain	0.963	0.979	0.976	0.977	0.972	0.861	0.986	0.984	0.985	0.972	0.962	0.962	0.941	0.984	0.984	0.972	0.980	0.993	0.985	1.000	0.989	0.979	0.969	0.984	0.990	0.982	0.982	0.989	0.976	0.975
ADM (Montezuma)	0.968	0.986	0.977	0.981	0.982	0.878	0.979	0.987	0.988	0.976	0.968	0.968	0.950	0.987	0.987	0.980	0.982	0.986	0.987	0.989	1.000	0.984	0.974	0.983	0.985	0.983	0.982	0.995	0.981	0.978
Alliance Ag	0.968	0.979	0.975	0.976	0.982	0.874	0.970	0.982	0.984	0.979	0.973	0.974	0.951	0.990	0.990	0.987	0.980	0.976	0.979	0.979	0.984	1.000	0.984	0.972	0.977	0.977	0.976	0.985	0.987	0.976
Offerle Coop	0.962	0.977	0.974	0.971	0.979	0.860	0.968	0.978	0.975	0.978	0.980	0.980	0.967	0.981	0.983	1.000	0.980	0.969	0.972	0.969	0.974	0.984	1.000	0.965	0.967	0.967	0.967	0.977	0.986	0.975
Elkart Coop	0.966	0.973	0.971	0.976	0.968	0.866	0.978	0.983	0.983	0.966	0.964	0.964	0.944	0.977	0.977	0.967	0.973	0.988	0.984	0.984	0.983	0.972	0.965	1.000	0.991	0.982	0.982	0.984	0.971	0.969
Skyland Grain	0.968	0.973	0.973	0.976	0.969	0.869	0.984	0.985	0.985	0.968	0.965	0.965	0.946	0.980	0.979	0.970	0.976	0.996	0.988	0.990	0.985	0.977	0.967	0.991	1.000	0.986	0.986	0.986	0.974	0.970
Equity Exchange	0.967	0.972	0.973	0.975	0.971	0.871	0.976	0.981	0.982	0.965	0.964	0.965	0.939	0.979	0.979	0.971	0.974	0.985	0.983	0.982	0.983	0.977	0.967	0.982	0.986	1.000	1.000	0.986	0.976	0.965
Equity Exchange	0.966	0.971	0.973	0.975	0.971	0.871	0.975	0.981	0.982	0.964	0.963	0.964	0.939	0.978	0.978	0.971	0.973	0.984	0.982	0.982	0.982	0.976	0.967	0.982	0.986	1.000	1.000	0.986	0.975	0.964
ADM (Plains)	0.971	0.987	0.981	0.984	0.981	0.880	0.981	0.989	0.990	0.979	0.971	0.971	0.950	0.987	0.987	0.980	0.983	0.987	0.988	0.989	0.995	0.985	0.977	0.984	0.986	0.986	0.986	1.000	0.982	0.977
Meade Coop	0.966	0.983	0.977	0.974	0.981	0.870	0.976	0.978	0.977	0.974	0.975	0.975	0.962	0.987	0.987	0.984	0.980	0.976	0.974	0.976	0.981	0.987	0.986	0.971	0.974	0.976	0.975	0.982	1.000	0.976
Alliance Ag	0.959	0.974	0.966	0.968	0.980	0.862	0.968	0.976	0.975	0.979	0.969	0.969	0.970	0.988	0.988	0.988	0.986	0.972	0.970	0.975	0.978	0.976	0.975	0.969	0.970	0.965	0.964	0.977	0.976	1.000

Source: Geograin

As table 3.2. illustrates from the beginning of 2011 to August 2025, except for the two grain elevators with different start dates of data, throughout the region all grain elevators have noticeably high correlation. This suggests corn prices move in tandem with each other amongst the grain elevators in the area. This also suggests a fairly efficient market and likely not very many large discrepancies. Interestingly to note, Midland Marketing in LaCrosse was the least correlated to all grain elevators in the region. Since this town is the farthest northeast likely other factors are driving its pricing compared to the rest. Rush County, which the town resides in, also has fewer corn acres and total cattle inventory compared to most other counties in the region of the study. This could also suggest that it may not take in very much corn comparatively and does not have a strong demand for feed use compared to other counties in the area. The tables 3.3. 3.4. 3.5. 3.6. 3.7. 3.8. and 3.9. highlight the correlations specifically for the elevators under the same ownership.

Table 3.3. ADM Elevator's Correlations

ADM Correlations			
Grain Locations	ADM (Leoti)	ADM (Montezuma)	ADM (Plains)
ADM (Leoti)	1.000	0.986	0.987
ADM (Montezuma)	0.986	1.000	0.995
ADM (Plains)	0.987	0.995	1.000

Source: Geograin

Table 3.4. Garden City Coop Elevator's Correlations

Garden City Coop Correlations				
Grain Locations	Garden City Coop (Dighton)	Garden City Coop (Lakin)	Garden City Coop (Garden City)	Garden City Coop (Ulysses)
Garden City Coop (Dighton)	1.000	0.990	0.993	0.990
Garden City Coop (Lakin)	0.990	1.000	0.995	0.991
Garden City Coop (Garden City)	0.993	0.995	1.000	0.996
Garden City Coop (Ulysses)	0.990	0.991	0.996	1.000

Source: Geograin

Table 3.5. Skyland Grain Elevator's Correlations

Skyland Grain Correlations				
Grain Locations	Skyland Grain (Syracuse)	Skyland Grain (Johnson City)	Skyland Grain (Sublette)	Skyland Grain (Rolla)
Skyland Grain (Syracuse)	1.000	0.994	0.986	0.984
Skyland Grain (Johnson City)	0.994	1.000	0.993	0.996
Skyland Grain (Sublette)	0.986	0.993	1.000	0.990
Skyland Grain (Rolla)	0.984	0.996	0.990	1.000

Source: Geograin

Table 3.6. Alliance Ag Grain Elevator's Correlations

Alliance Ag Correlations						
Grain Locations	Alliance Ag (Jetmore)	Alliance Ag (Dodge City)	Alliance Ag (Spearville)	Alliance Ag (Kinsley)	Alliance Ag (Minneola)	Alliance Ag (Coldwater)
Alliance Ag (Jetmore)	1.000	0.979	0.981	0.984	0.979	0.979
Alliance Ag (Dodge City)	0.979	1.000	0.999	0.988	0.990	0.988
Alliance Ag (Spearville)	0.981	0.999	1.000	0.989	0.990	0.988
Alliance Ag (Kinsley)	0.984	0.988	0.989	1.000	0.980	0.986
Alliance Ag (Minneola)	0.979	0.990	0.990	0.980	1.000	0.976
Alliance Ag (Coldwater)	0.979	0.988	0.988	0.986	0.976	1.000

Source: Geograin

Table 3.7. Golden Valley Grain Elevator's Correlations

Golden Valley Correlations		
Grain Locations	Golden Valley (Burdett)	Golden Valley (Larned)
Golden Valley (Burdett)	1.000	1.000
Golden Valley (Larned)	1.000	1.000

Source: Geograin

Table 3.8. OfferleCoop Grain Elevator's Correlations

Offerle Coop Correlations		
Grain Locations	Offerle Coop (Spearville)	Offerle Coop (Bucklin)
Offerle Coop (Spearville)	1.000	1.000
Offerle Coop (Bucklin)	1.000	1.000

Source: Geograin

Table 3.9. Equity Exchange Grain Elevator's Correlations

Equity Exchange Correlations		
Grain Locations	Equity Exchange (Hugoton)	Equity Exchange (Liberal)
Equity Exchange (Hugoton)	1.000	1.000
Equity Exchange (Liberal)	1.000	1.000

Source: Geograin

Tables 3.3.-3.9. reinforce the high correlation among same ownership grain elevators even across significant distances. It also highlights the elevators under same ownership that are close geographically to be nearly perfectly correlated. Moreover, in the case of the companies of Golden Valley, Offerle Coop, and Equity Exchange they indeed were perfectly correlated, holding the exact same basis values or nearly the same with the rounding of the correlation value.

Lastly, another measure to provide further information on the relationship among all grain elevators is not just correlations of the basis values, but the week over week differences in basis at each grain elevator all correlated against each other (correlations of first-differences in basis values). This specifically measures the relationship in the change of basis between all elevators in the region. This measure takes out patterns such as seasonality, trends, or large-scale effects such as changes in futures prices. Similarly to table 3.2., table 3.10. highlights the week-over-week differences in basis correlations. This analysis can provide more meaning to the basis values that the simple correlations do not highlight.

Table 3.10. highlights that grain elevators farther apart geographically aren't as related as the correlation of the values in basis alone suggest. Which isn't surprising, the farther away markets are from each other the less likely they will move by the same magnitude. There is county to county differences in supply and demand of corn. However, the highly correlated values in basis itself from earlier, suggest that similar factors drive basis as a whole in the region. Again, economically this makes sense, confirming our expectations that dynamics in the area are similar such as strong demand for corn as feed. Similarly to the previous correlations we see basis at Midland Marketing in LaCrosse, does not show very much relation to the other grain elevators. In addition, we also see this for DE Bondurant Grain at Ness City, CHS at Tribune, and Pawnee County Coop at Larned. It is also exhibited but not as strongly for the Offerle Coop locations, Equity Exchange locations, and Alliance Ag at Coldwater as well. What these grain elevators all have in common, is that they tend to be bordering around the outside counties of the Southwest Kansas region that was defined for this study. This can also be rationalized by likely other factors that may be influencing the basis of these outside grain elevators, compared to the grain elevators in the heart of Southwest Kansas.

Table 3.10. Week-Over-Week Differences Pearson Correlation Table of All 30 Grain Elevators

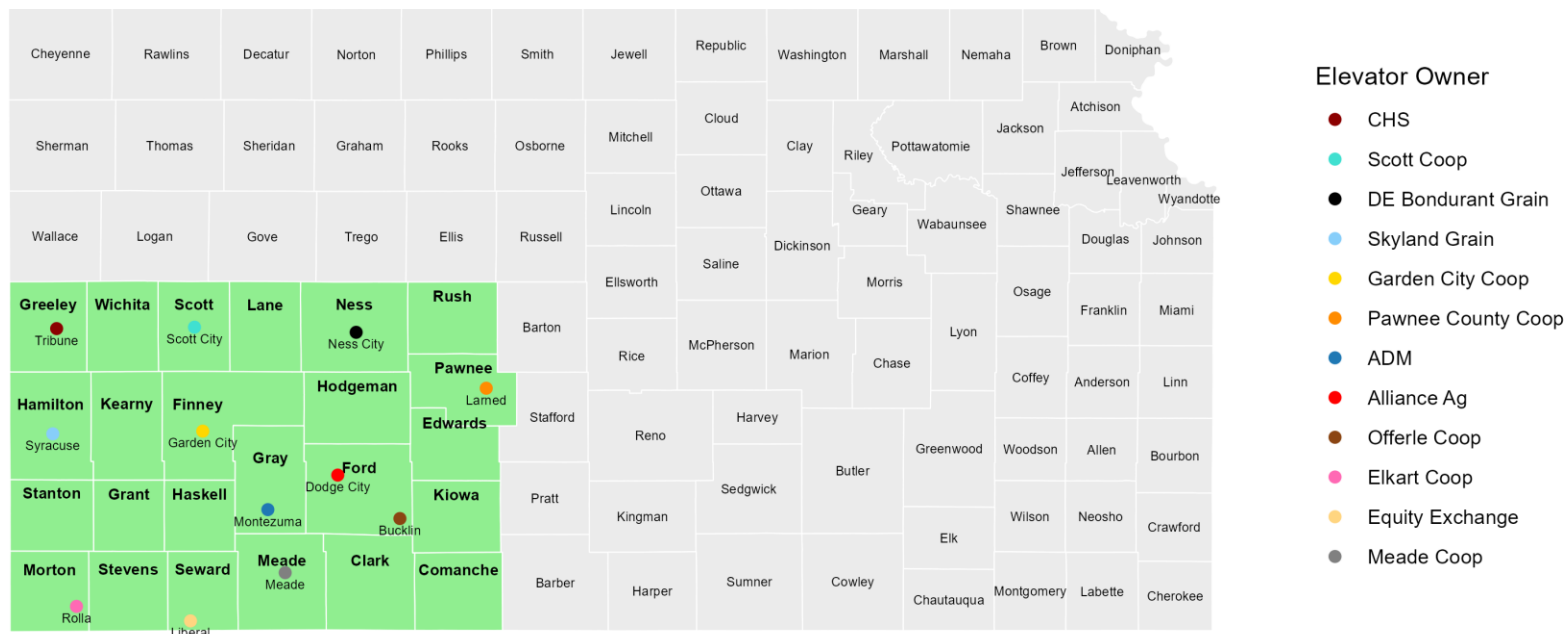
Grain Locations	CHS (Tribune)	ADM (Leoti)	Scott Coop (Scott City)	Garden City Coop (Dighton)	DE Bondurant Grain (Ness City)	Midland Marketing (LaCrosse)	Skyland Grain (Syracuse)	Garden City Coop (Lakin)	Garden City Coop (Garden City)	Alliance Ag (Jetmore)	Golden Valley (Burdett)	Golden Valley (Larned)	Pawnee County Coop (Larned)	Alliance Ag (Dodge City)	Alliance Ag (Spearville)	Offerle Coop (Spearville)	Alliance Ag (Kinsley)	Skyland Grain (Johnson City)	Garden City Coop (Ulysses)	Skyland Grain (Sublette)	ADM (Montezuma)	Alliance Ag (Minneapolis)	Offerle Coop (Bucklin)	Elkart Coop (Rolla)	Skyland Grain (Rolla)	Equity Exchange (Hugoton)	Equity Exchange (Liberal)	ADM (Plains)	Meade Coop (Meade)	Alliance Ag (Coldwater)
CHS (Tribune)	1.000	0.492	0.662	0.628	0.434	0.347	0.600	0.645	0.641	0.476	0.529	0.519	0.514	0.509	0.511	0.347	0.435	0.610	0.645	0.565	0.497	0.542	0.582	0.516	0.608	0.554	0.542	0.526	0.515	0.412
ADM (Leoti)	0.492	1.000	0.687	0.731	0.640	0.375	0.749	0.745	0.742	0.710	0.623	0.610	0.595	0.740	0.738	0.579	0.715	0.757	0.734	0.740	0.785	0.626	0.671	0.671	0.749	0.655	0.630	0.847	0.778	0.644
Scott Coop	0.662	0.687	1.000	0.841	0.460	0.394	0.771	0.827	0.829	0.677	0.757	0.723	0.539	0.644	0.652	0.532	0.585	0.784	0.823	0.759	0.632	0.742	0.762	0.640	0.785	0.687	0.664	0.701	0.689	0.501
Garden City Coop	0.628	0.731	0.841	1.000	0.607	0.371	0.756	0.884	0.951	0.713	0.673	0.652	0.554	0.714	0.722	0.573	0.654	0.768	0.935	0.759	0.684	0.680	0.726	0.628	0.768	0.648	0.621	0.754	0.695	0.593
DE Bondurant Grain	0.434	0.640	0.460	0.607	1.000	0.247	0.522	0.628	0.622	0.518	0.530	0.530	0.381	0.637	0.650	0.606	0.552	0.558	0.621	0.534	0.629	0.504	0.606	0.439	0.546	0.514	0.514	0.635	0.575	0.633
Midland Marketing	0.347	0.375	0.394	0.371	0.247	1.000	0.403	0.381	0.380	0.305	0.380	0.362	0.332	0.350	0.353	0.144	0.289	0.409	0.381	0.383	0.345	0.363	0.381	0.363	0.406	0.360	0.347	0.416	0.373	0.293
Skyland Grain	0.600	0.749	0.771	0.756	0.522	0.403	1.000	0.776	0.774	0.742	0.743	0.726	0.644	0.713	0.720	0.510	0.724	0.989	0.791	0.902	0.730	0.678	0.700	0.753	0.984	0.734	0.702	0.802	0.730	0.594
Garden City Coop	0.645	0.745	0.827	0.884	0.628	0.381	0.776	1.000	0.922	0.736	0.688	0.665	0.580	0.727	0.735	0.653	0.672	0.789	0.927	0.767	0.707	0.688	0.755	0.659	0.791	0.666	0.639	0.778	0.692	0.619
Garden City Coop	0.641	0.742	0.829	0.951	0.622	0.380	0.774	0.922	1.000	0.723	0.675	0.652	0.566	0.726	0.733	0.614	0.664	0.788	0.965	0.769	0.714	0.687	0.739	0.646	0.786	0.658	0.631	0.787	0.697	0.606
Alliance Ag	0.476	0.710	0.677	0.713	0.518	0.305	0.742	0.736	0.723	1.000	0.650	0.642	0.621	0.800	0.808	0.578	0.901	0.751	0.719	0.773	0.702	0.638	0.640	0.669	0.758	0.611	0.577	0.770	0.636	0.738
Golden Valley	0.529	0.623	0.757	0.673	0.530	0.380	0.743	0.688	0.675	0.650	1.000	0.985	0.548	0.566	0.576	0.615	0.528	0.751	0.677	0.690	0.571	0.768	0.801	0.608	0.753	0.665	0.624	0.635	0.756	0.423
Golden Valley	0.519	0.610	0.723	0.652	0.530	0.362	0.726	0.665	0.652	0.642	0.985	1.000	0.522	0.544	0.550	0.615	0.514	0.734	0.652	0.670	0.560	0.761	0.790	0.584	0.736	0.644	0.603	0.623	0.746	0.396
Pawnee County	0.514	0.595	0.539	0.554	0.381	0.332	0.644	0.580	0.566	0.621	0.548	0.522	1.000	0.684	0.690	0.355	0.666	0.642	0.578	0.628	0.585	0.488	0.524	0.651	0.649	0.567	0.539	0.624	0.571	0.646
Alliance Ag	0.509	0.740	0.644	0.714	0.637	0.350	0.713	0.727	0.726	0.800	0.566	0.544	0.684	1.000	0.991	0.676	0.851	0.723	0.729	0.752	0.698	0.596	0.633	0.689	0.722	0.622	0.584	0.767	0.642	0.886
Alliance Ag	0.511	0.738	0.652	0.722	0.650	0.353	0.720	0.735	0.733	0.808	0.576	0.550	0.690	0.991	1.000	0.678	0.858	0.730	0.735	0.767	0.704	0.600	0.635	0.695	0.730	0.634	0.597	0.774	0.650	0.891
Offerle Coop	0.347	0.579	0.532	0.573	0.606	0.144	0.510	0.653	0.614	0.578	0.615	0.615	0.355	0.676	0.678	1.000	0.584	0.548	0.610	0.526	0.588	0.618	1.000	0.460	0.527	0.528	0.529	0.606	0.609	0.694
Alliance Ag	0.435	0.715	0.585	0.654	0.552	0.289	0.724	0.672	0.664	0.901	0.528	0.514	0.666	0.851	0.858	0.584	1.000	0.727	0.672	0.759	0.688	0.523	0.538	0.683	0.727	0.591	0.558	0.753	0.576	0.834
Skyland Grain	0.610	0.757	0.784	0.768	0.558	0.409	0.989	0.789	0.788	0.751	0.751	0.734	0.642	0.723	0.730	0.548	0.727	1.000	0.805	0.900	0.740	0.694	0.716	0.768	0.990	0.739	0.706	0.814	0.735	0.601
Garden City Coop	0.645	0.734	0.823	0.935	0.621	0.381	0.791	0.927	0.965	0.719	0.677	0.652	0.578	0.729	0.735	0.610	0.672	0.805	1.000	0.775	0.717	0.691	0.733	0.660	0.804	0.655	0.627	0.786	0.689	0.601
Skyland Grain	0.565	0.740	0.759	0.759	0.534	0.383	0.902	0.767	0.769	0.773	0.690	0.670	0.628	0.752	0.767	0.526	0.759	0.900	0.775	1.000	0.744	0.650	0.682	0.746	0.896	0.706	0.675	0.797	0.711	0.663
ADM (Montezuma)	0.497	0.785	0.632	0.684	0.629	0.345	0.730	0.707	0.714	0.702	0.571	0.560	0.585	0.698	0.704	0.588	0.688	0.740	0.717	0.744	1.000	0.601	0.616	0.643	0.737	0.641	0.613	0.859	0.704	0.611
Alliance Ag	0.542	0.626	0.742	0.680	0.504	0.363	0.678	0.688	0.687	0.638	0.768	0.761	0.488	0.596	0.600	0.618	0.523	0.694	0.691	0.650	0.601	1.000	0.817	0.493	0.700	0.553	0.524	0.667	0.743	0.428
Offerle Coop	0.582	0.671	0.762	0.726	0.606	0.381	0.700	0.755	0.739	0.640	0.801	0.790	0.524	0.633	0.635	1.000	0.538	0.716	0.733	0.682	0.616	0.817	1.000	0.574	0.717	0.624	0.587	0.679	0.789	0.472
Elkart Coop	0.516	0.671	0.640	0.628	0.439	0.363	0.753	0.659	0.646	0.669	0.608	0.584	0.651	0.689	0.695	0.460	0.683	0.768	0.660	0.746	0.643	0.493	0.574	1.000	0.766	0.671	0.644	0.692	0.683	0.635
Skyland Grain	0.608	0.749	0.785	0.768	0.546	0.406	0.984	0.791	0.786	0.758	0.753	0.736	0.649	0.722	0.730	0.527	0.727	0.990	0.804	0.896	0.737	0.700	0.717	0.766	1.000	0.736	0.703	0.810	0.728	0.599
Equity Exchange	0.554	0.655	0.687	0.648	0.514	0.360	0.734	0.666	0.658	0.611	0.665	0.644	0.567	0.622	0.634	0.528	0.591	0.739	0.655	0.706	0.641	0.553	0.624	0.671	0.736	1.000	0.976	0.695	0.711	0.509
Equity Exchange	0.542	0.630	0.664	0.621	0.514	0.347	0.702	0.639	0.631	0.577	0.624	0.603	0.539	0.584	0.597	0.529	0.558	0.706	0.627	0.675	0.613	0.524	0.587	0.644	0.703	0.976	1.000	0.665	0.669	0.481
ADM (Plains)	0.526	0.847	0.701	0.754	0.635	0.416	0.802	0.778	0.787	0.770	0.635	0.623	0.624	0.767	0.774	0.606	0.753	0.814	0.786	0.797	0.859	0.667	0.679	0.692	0.810	0.695	0.665	1.000	0.755	0.673
Meade Coop	0.515	0.778	0.689	0.695	0.575	0.373	0.730	0.692	0.697	0.636	0.756	0.746	0.571	0.642	0.650	0.609	0.576	0.735	0.689	0.711	0.704	0.743	0.789	0.683	0.728	0.711	0.669	0.755	1.000	0.496
Alliance Ag	0.412	0.644	0.501	0.593	0.633	0.293	0.594	0.619	0.606	0.738	0.423	0.396	0.646	0.886	0.891	0.694	0.834	0.601	0.601	0.663	0.611	0.428	0.472	0.635	0.599	0.509	0.481	0.673	0.496	1.000

Source: Geograin

There are several key points from this initial analysis to support a decision criterion for the selected grain elevators to model basis for. As mentioned earlier with the significance of the larger grain companies, especially with their location in the heart of Southwest Kansas, they are excellent choices to represent basis in Southwest Kansas, and they should be selected to model. This includes Garden City Coop, Alliance Ag, Skyland Grain, and ADM. The high correlation between grain elevators under the same ownership, regardless of their distance from each other, also suggests it is redundant to select multiple grain elevators of the same company. The total amount of corn acres and cattle inventory in respective counties of grain elevators were also utilized in consideration for the selections, since those are main variables, this study seeks to measure. Garden City and Dodge City were selected to represent Garden City Coop and Alliance Ag respectively because of these reasons and since they are larger towns and likely that is where they are headquartered. Montezuma for ADM and Syracuse for Skyland Grain were selected for their respective companies, also for similar discussed reasoning and for geographic representation. Geographic representation was another consideration to ensure most areas of the region all had an elevator for representation. Lastly, the selection of the remaining elevators followed a rule with the week over week differences correlations and a couple exceptions. If the remaining elevators' differences correlations were greater than or equal to 80% correlation to the ones already selected then they were removed, if they were 80% or greater correlated to each other then only one would be selected. This was the case with the Golden Valley elevators; they were equal to or above 80% correlated with the Offerle Coop locations and Bucklin was selected based on geographic representation since the others were much closer to other locations.

For the two exceptions to this rule that were made, the first included Scott City. Scott Coop was above 80% correlated to Garden City however it was still selected since it's county was one of the largest with cattle inventory and a high corn acreage. It is a large and important market in the area, so it was selected despite the correlation to Garden City Coop. Midland Marketing at LaCrosse was also removed even though it was less than 80% correlated compared to the others. This elevator was significantly uncorrelated with the rest and likely did not have any solid relation to the factors of this region. It was determined to likely not provide value, so it was removed. Outside of these two exceptions the discussed framework was used to determine the selected grain elevators for the modeling. Figure 3.3. illustrates a map of these selected elevators.

Figure 3.3. Selected Grain Elevators for County Level Models

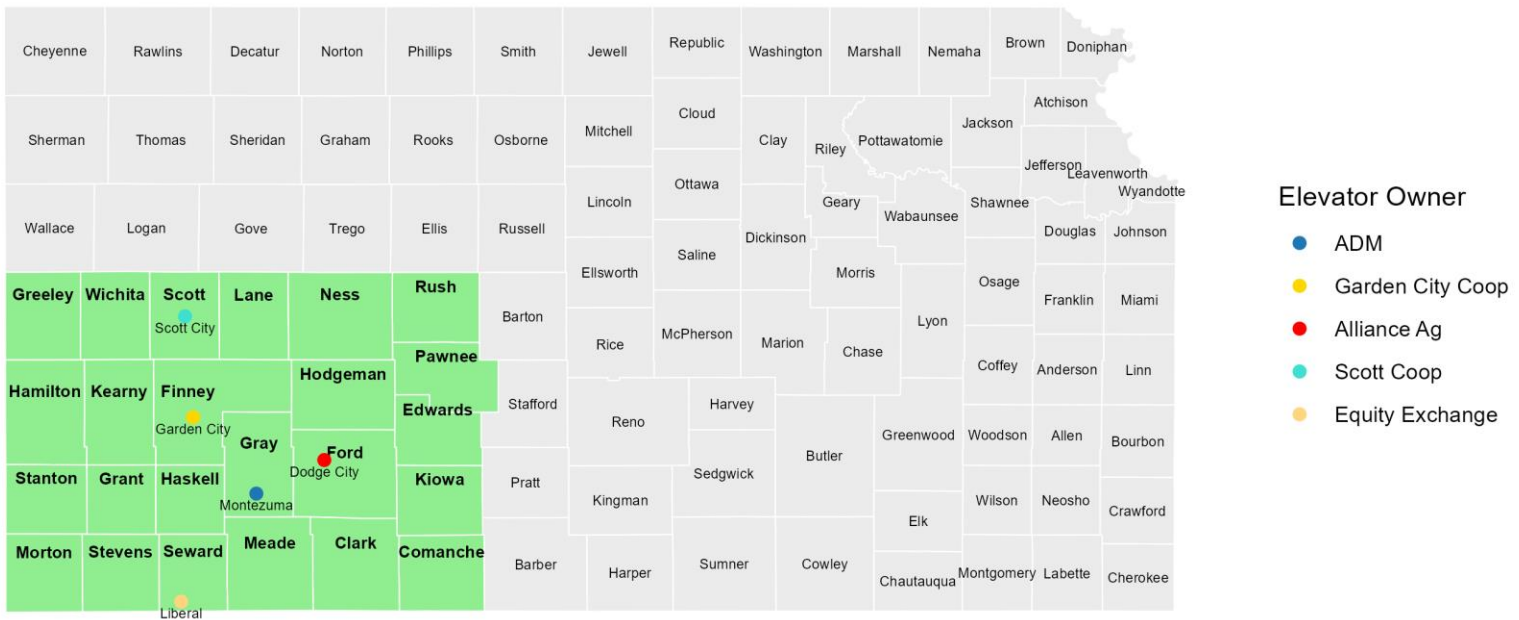


Sources: TIGER/Line via tigris

The selected grain elevators were modeled utilizing county level data for their independent variables since it was available. These models were designed to add depth to the study and additional granular detail. Since these 14 grain elevators were again slimmed down to provide models that represent and examine corn basis as a single value in Southwest Kansas for the region. These new models would incorporate the region level's independent data or all Southwest Kansas county level independent variable data summed together. These models will be the focus of the study and be the primary ones to provide information on the changes in economic factors affecting corn basis for the region.

The first model of this macro level approach is an average of all 30 grain elevators' basis, to represent a singular corn basis for the region. Then the following models utilize the elevators of Scott Coop at Scott City, Garden City Coop at Garden City, Alliance Ag at Dodge City, ADM at Montezuma, and Equity Exchange at Liberal to represent Southwest Kansas basis individually. Garden City, ADM, and Alliance Ag at their respective towns were selected based on earlier rationale already discussed, and Scott Coop and Equity Exchange at their respective towns were selected to represent a northern and southern edge of the region. Equity Exchange at Liberal was chosen over Skyland Grain, even though Skyland did have a larger geographic footprint, because of Liberal's location, as a farther south elevator, and because of the factors of Seward County, for which it resides in. Seward County has a greater cattle inventory and more corn acres than Hamilton County where the selected Skyland Grain location is. Since these are the main variables of focus for this study, this location was determined to be more representative for this region's corn basis. Figure 3.4. shows these representative corn basis elevators on a map that will be modeled to primarily explain the macro level factors in the region that are influencing corn basis.

Figure 3.4. Selected Grain Elevators for Regional Models

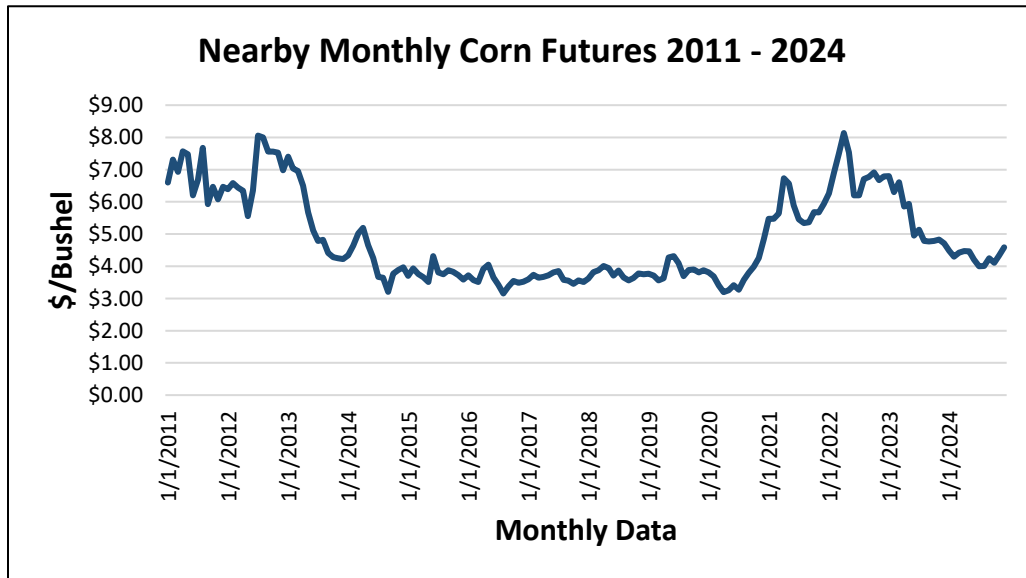


Sources: TIGER/Line via tigris

3.2 Corn Futures

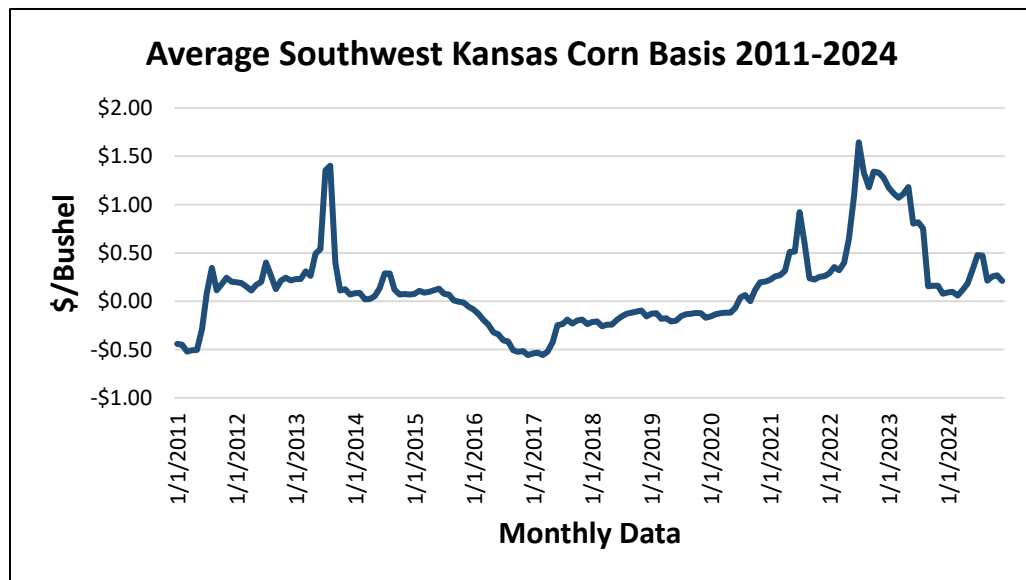
The Monthly Nearby Corn Futures data for the models was sourced from Barchart Prices and Quotes. A time series from 2011 to 2024 was selected to match the available corn basis data. The models do not include the year 2025 since at the time of this analysis 2024 is the latest available complete year. Nearby Monthly Corn Futures were utilized to ensure each basis month would line up with the appropriate futures contract at that time. Figure 3.5. provides some insight into corn futures behavior during this time frame. Figure 3.6. is the representative monthly average corn basis in Southwest Kansas for comparison. As the two figures suggest there is some resemblance in movement of corn pricing. However, it also shows times when corn basis movement is independent of corn futures as well. This can illustrate the difference between corn supply and demand in the region compared to a national or a global level.

Figure 3.5. Nearby Monthly Corn Futures



Source: Barchart

Figure 3.6. Representative Average Southwest Kansas Corn Basis Chart

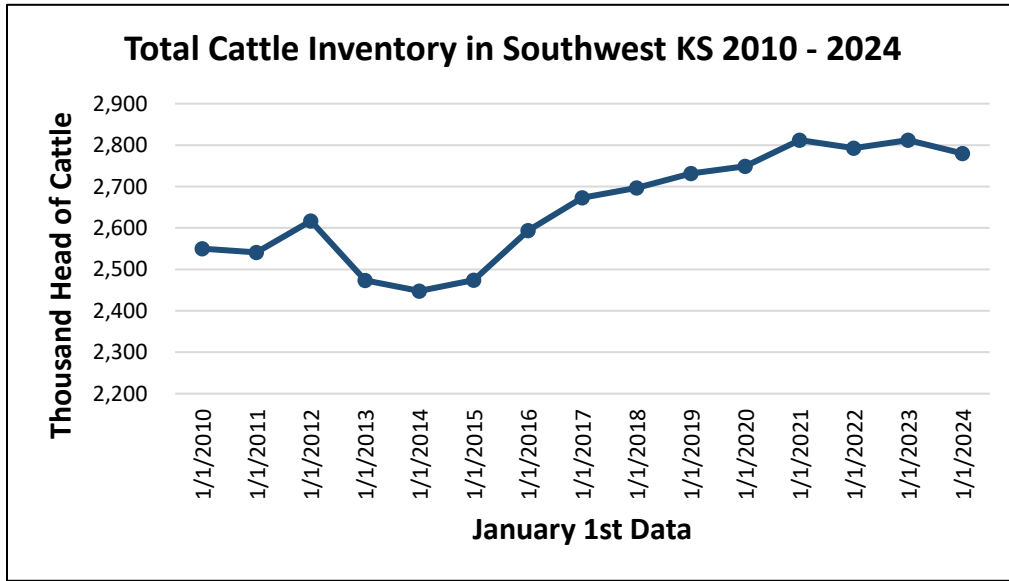


Source: Geograin

3.3 Cattle Inventory

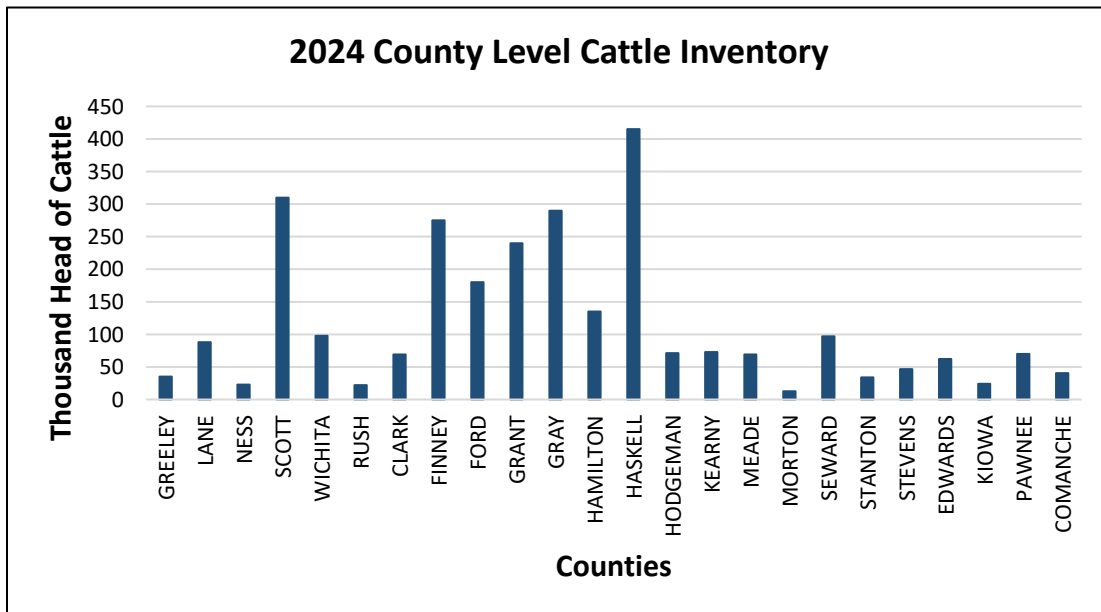
Total cattle inventory data for all the counties in the Southwest Kansas region was sourced as survey data from USDA, NASS. Total cattle inventory includes all cattle and calves in a county. The data for this specific category was only available annually on the first of every January. So, a limiting factor for this variable is it is assumed to be constant throughout the year. This is because the January cattle inventory value of each year is used to represent every month for the models. This was the most complete and granular data available on NASS relating to cattle in this region. Cattle on feed was the original variable anticipated for use, however it did not have sufficient and recent data. Total cattle inventory on a county level was used for each individual grain elevator model and all counties cattle inventory in the region summed together was used for the Southwest Kansas representative models. Figure 3.7. illustrates total cattle inventory in the region over time and figure 3.8. showcases cattle inventory per county for the year 2024.

Figure 3.7. Total Cattle Inventory in Southwest Kansas Over Time



Source: USDA NASS

Figure 3.8. 2024 County Level Cattle Inventory



Source: USDA NASS

Figure 3.7. suggests a strong and steady growth in cattle production starting in 2015 then plateauing in 2021. This further supports that cattle inventory should play a strong part in explaining the variation in corn basis for this study. Figure 3.8. illustrates which counties hold the most cattle in 2024. Haskell County held the most cattle with 415,000 in the region. Other counties such as Scott, Gray, and Finney were also notable with 310,000, 290,000 and 275,000, head respectively.

3.4 Corn Acres Planted

Similar to total cattle inventory, surveyed corn acres planted for each model was sourced from USDA NASS. One drawback of using corn acres to represent supply of corn is that the granularity does not match with monthly variables. Again, like the case in total cattle inventory, corn acres are a single value each year and it must be used as the same number for all 12 months. However, for examining a small region this is the best and measurable choice to represent corn supply. USDA NASS has “Agricultural Districts” in each state that cover a certain region of that state. In Kansas there is a southwest district, however, compared to the definition of Southwest Kansas specific for this study it includes a smaller area in comparison. This study’s definition of Southwest Kansas includes another row of counties to the north and another column of counties to the east. Or specifically the counties of Greeley, Wichita, Scott, Lane, Ness, Rush, Pawnee, Edwards, Kiowa, and Commanche. For the Southwest Kansas corn basis representative models, they utilized total corn acres planted in the region from USDA’s Southwest KS Agricultural District, plus all the individual counties’ corn acres listed above. Similarly to the total cattle inventory variable, for the individual elevator models, they used the corn acres planted in their respective counties.

However, similar to corn basis in this region, corn acres planted for each county were not always recorded each year in USDA's NASS database. A strategy for proxies had to be utilized to provide a full data set. For Agricultural Districts in the USDA NASS database the years 2008 to 2019, each have an "Other Combined Counties" section where all counties that were missing planted acres would be provided altogether as a residual. USDA likely has this rule in place for privacy reasons for producers. For example, if there are too few producers in the county that plant most of the corn acres, this could create potential confidentiality issues. By providing a residual each year for the Southwest District, this covers most of the corn acres required for the regional level corn basis models. However, for the other counties not included in USDA's Southwest District, all the individual elevator models that use county data that has certain years missing, and after the year 2019 that does not have a residual provided, proxies for these missing corn acre values had to be implemented.

For the individual grain elevator models, that utilize county level data, all the counties had at least one year of missing planted corn acres. To fill in these missing years, the specific county that was currently examined would be regressed on multiple other counties' corn acres that share a same border with the missing county. Then the counties with the highest R squared would be used to estimate the missing values. This was determined to be the best approach to estimate missing corn acres planted; however, a drawback to this is that it assumes the other counties can always explain the variation and it does not account for specific county changes or reactions. Often not a single bordering county would have every year required to match all the missing values for the estimations. So, two to three counties would frequently be used to estimate all the missing values. If there were models with similar R Squares the county with the average amount of acres that was most similar to the one being estimated would be used first,

then counties that had the larger amount of acres would be used if the rest were significantly smaller, if a county had a smaller portion of the boarder that was shared compared to the other counties, they would be avoided to be used first, and lastly if a county bordering had significantly fewer acres in comparison they would be the last resort. This was performed to fill in missing values for all counties used in the individual elevator models, all counties bordering the outside of USDA NASS's Southwest Kansas Agricultural District, since these are counties used for this study, and for just the counties that had missing values in years from 2020-2024, that were in NASS's Southwest District. Since those values were missing in the district, because the residual is provided only until 2019.

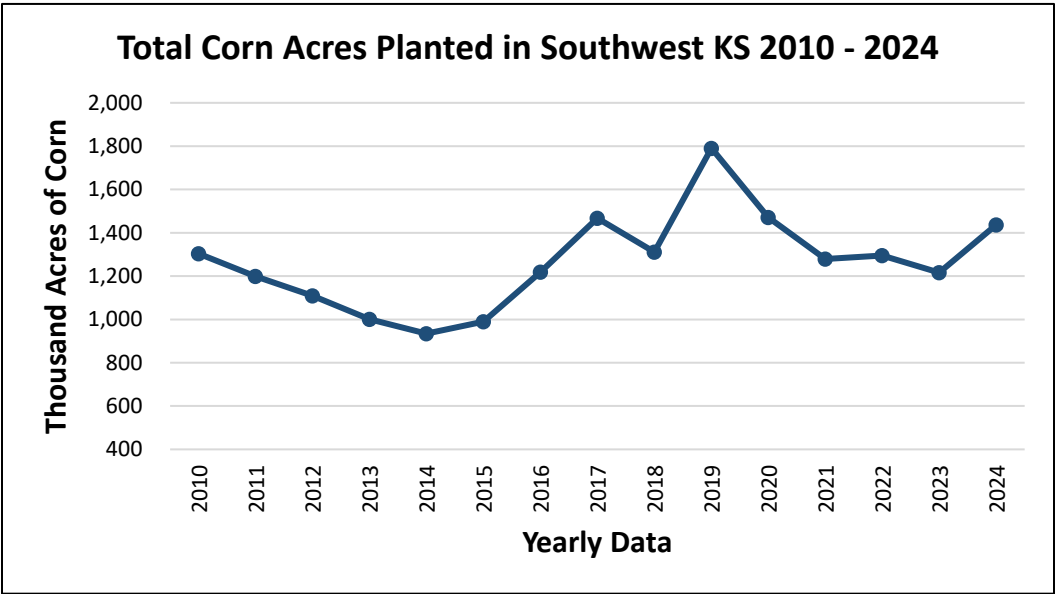
Another strategy implemented to provide more grounded accuracy for just a couple years was to use Agricultural Census data if the counties were missing years, such as 2017 and 2022. Agricultural Census data is USDA's estimates for agricultural statistics made every 5 years instead of survey data. There weren't recorded planted acres under Census data but there were recorded harvested acres for those years on a county level. So, for a specific county the average percent of acres harvested to planted from the years 1990 to 2024, with at least all its available years, were taken. Then that would be divided by the harvested Census data for that year, and that would represent corn acres planted. The years 1990 to 2024 for the average were selected to ensure enough values for a reasonable calculation. More of the missing values for each county were in years outside of 2017 and 2022 but for the ones that did fall on these years, this strategy was implemented.

A few special circumstances were made as well, for the county of Commanche, all regressions R Squares to predict missing values were all under 0.1, and since so few corn acres are planted in this county, the average of available years was used to fill in the missing ones.

Which was just below 3,000 acres, very small compared to most of all the other counties. Also, oddly in NASS in 2010 Finney County corn acres planted were missing yet acres harvested were collected. All other corn acres harvested would always be recorded in the same year corn acres planted would be in the survey data in NASS. Moreover, the residual in 2010 for the Southwest KS Ag District was similar in similar proportion for both the harvested and planted acres. This suggests that for the planted acres the residual did not include Finney County that year. So similarly to the planted acre calculations on Ag Census years, the average percent of corn acres harvested to planted was divided by Census harvested acres to have a value for Finney County's planted acres in 2010. Outside of these small corrections the strategies described above were implemented for all other missing values.

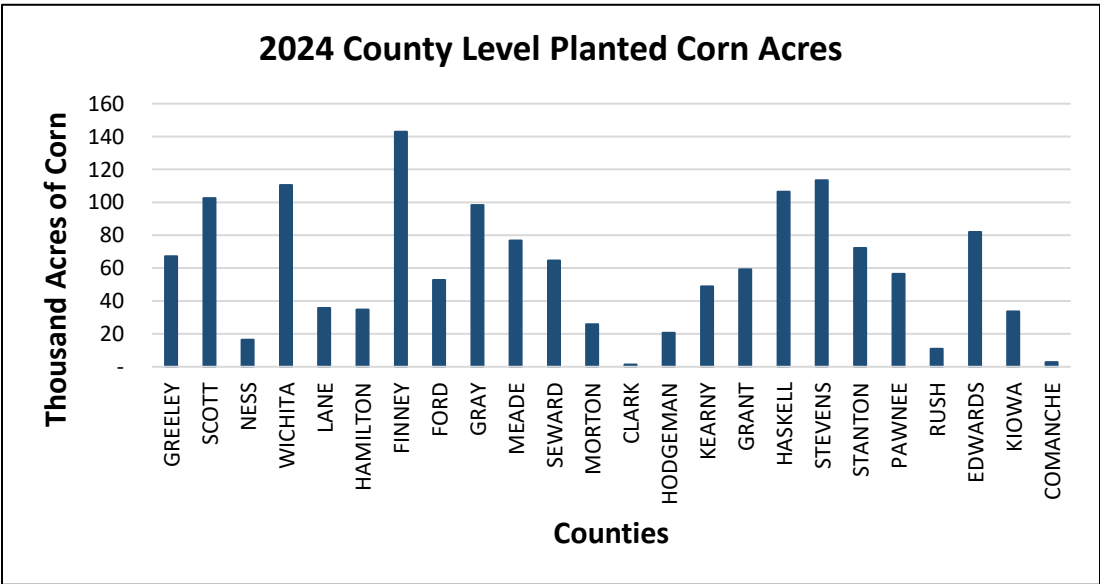
Figure 3.9. highlights total corn acres planted in the region of study over time. It shows in recent years that the average is more elevated than compared to the past. This graph indicates after the year 2014 corn acres changed trend to increasing production and since 2020 it has seemed to cut back to an extent and level off. This along with figure 3.7. illustrating cattle inventory in the region, helped determine to select a time frame of 2015 to 2024 for all the basis models of this study. With both of these major economic factors in the region experiencing change, this selection should provide more accuracy for the models. This indication by figures 3.7. and 3.9. suggest that this region has experienced structural change with these higher numbers for the past 10 years. Figure 3.9. also illustrates corn acres in the region can be volatile, and potentially other incentives may be in play. Other factors with influence could be futures prices or drought and weather. These could both encourage or discourage total corn acres planted. Figure 3.8. is a breakdown of 2024 corn acres per county to illustrate the counties with the most corn production.

Figure 3.9. Corn Acres Planted in Southwest Kansas Over Time



Source: USDA NASS

Figure 3.10. 2024 County Level Planted Corn Acres



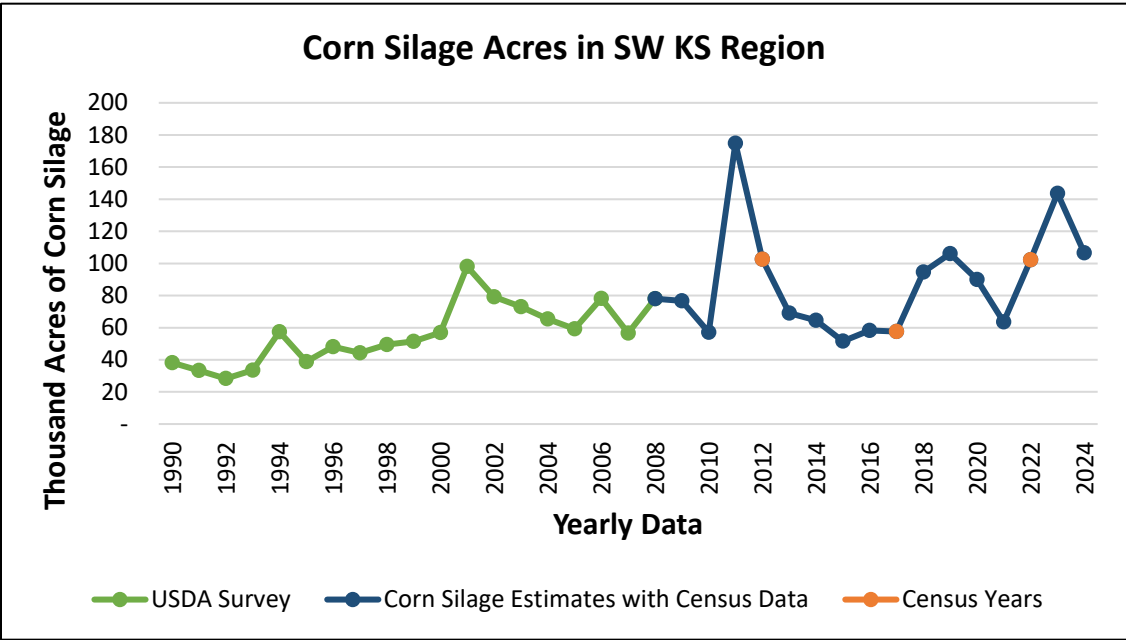
Source: USDA NASS

3.5 Corn Silage Acres

Corn Silage Acres harvested were also sourced from USDA NASS. Similarly, they also were collected as a total from the Southwest KS district, and then all the individual counties required for this study were collected as well. A problem with this variable's data set was that USDA NASS stopped collecting data for it since 2008 for the Southwest Ag District and stopped collecting data since 2007 for all the other counties. Similar strategies of utilizing regression models to predict missing year values were employed, however since all the data was missing for the selected time frame this variable will be the largest implication of the study. This will be a drawback to the models since proxies were used for all the values of the time frame. The solution may not be a perfect representation; however, it still does hold a degree of accuracy. Maintaining the plan to incorporate the corn silage variable was also deemed important for its assumed growth presence in the region, and to help answer some of the questions of this study. To determine values for corn silage in each county and for each year, the years from 1990 to the latest available data for corn silage before USDA NASS stopped collecting, was modeled as a function of the difference between corn acres planted and harvested. Then these models were used to predict corn silage acres for each year until 2024. Note similar to corn acres planted, not all counties would have each year's corn harvested acres recorded either. In fact, they would be the same years of missing data for each county for both planted and harvested data. So just like planted acres from before, the same exact surrounding counties were modeled to predict the same counties' harvested acres on missing years. In addition, just like planted acres Ag Census values were used if counties were missing in the years of 2017 or 2022. Once all missing harvested acres for each required county and the Ag Southwest District, just like corn acres planted were determined, then the difference of all planted and harvested acres could be solved

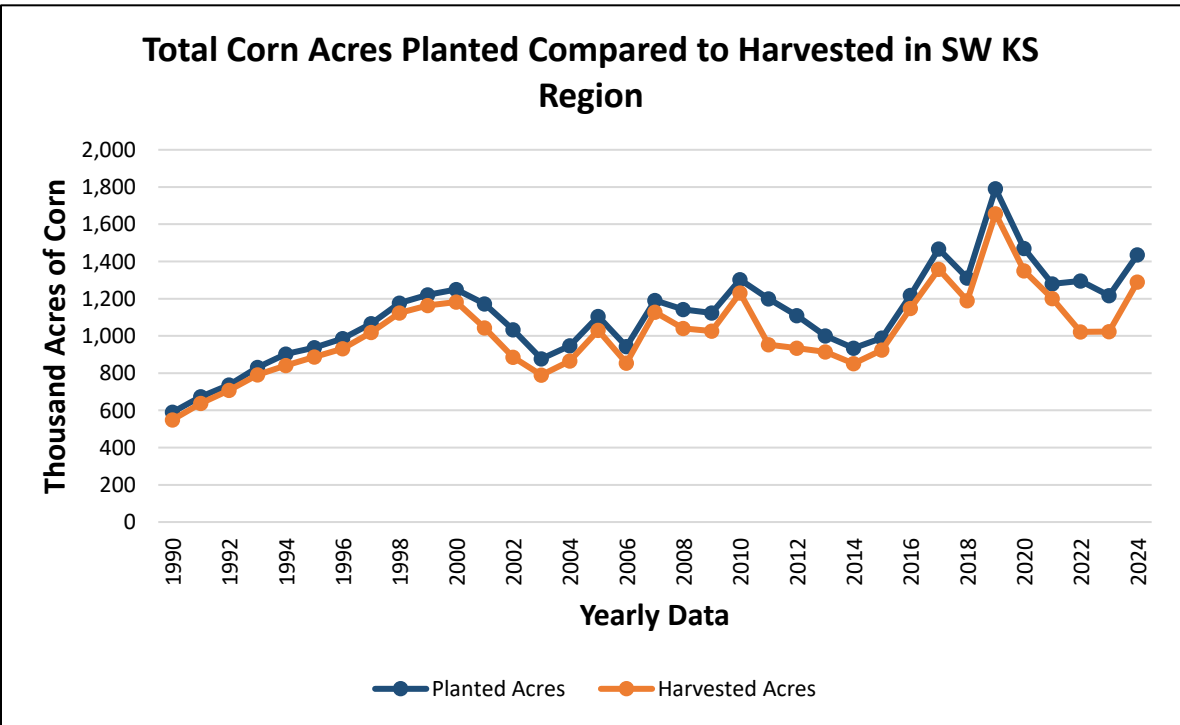
for. Then this difference could be used to solve the missing silage values with the silage models that were employed. Again, this was performed for the counties required for the individual grain elevator models and for USDA's Southwest KS District. Moreover, just like the corn acres, the corn silage acres observed on Census years were imputed. So at least two of the years had confirmed accurate silage numbers. Overall, this strategy uses the data available at hand but does assume the relationship of corn silage to both planted and harvested acres remains similar since the 1990s to the mid to late 2000s. This also may provide inaccurate results in drought years as well. Despite these tradeoffs this was determined to be the best course of action for this variable. For total corn silage acres in the region, like corn acres planted, the USDA's Southwest District was added to the summation of the surrounding counties not included in the district but still apart of the defined area of Southwest Kansas for this study. Figure 3.11. illustrates the survey USDA data from the 1990s and 2000s of corn silage for the region, then the calculated values, and lastly the Census years highlighted. Figure 3.10. shows corn acres planted and harvested both charted to show the consistent spread between the two.

Figure 3.11. Corn Silage Acres Harvested Over Time in Southwest Kansas



Source: USDA NASS

Figure 3.12. Corn Acres Planted Compared to Harvested in Southwest Kansas



Source: USDA NASS

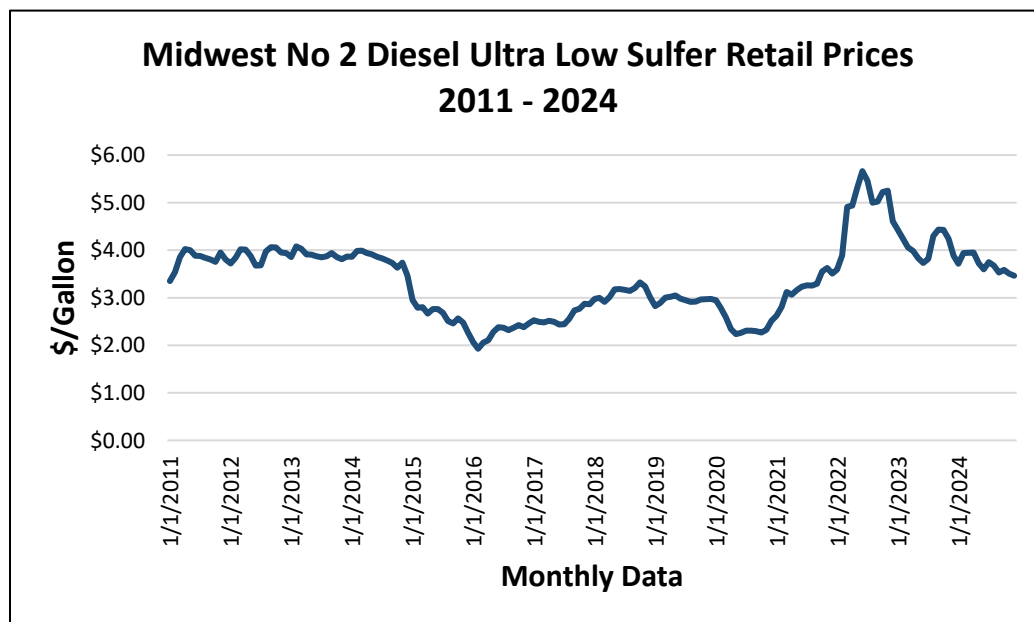
Figure 3.11. shows corn silage acres overtime, and it suggests a trend of increasing silage acres in recent years. This would also support our initial hypothesis; however the year of 2011 immediately catches the eye and is anomaly compared to the other years. Figure 3.11. indicates that corn silage is nearly 180,000 acres in 2011 which is significantly elevated compared to the other years. 2011 happened to be a drought year as well which could suggest a greater amount of corn acres were never harvested due to loss. Moreover, as stated before, a weakness of the method used to calculate the silage acres is that it assumes a consistent relationship with the difference of planted and harvested acres. The year 2011 is likely a case where the silage acres are overstated because of the drought. However, figure 3.12. suggests there tends to be a consistent spread between planted and harvested acres most years. With a consistent spread we can infer that corn silage acres likely have a strong relationship with this difference and that it is a reliable predictor for silage acres most years. However, as we can see in figure 3.12. as well, not only 2011 but also 2012, 2022, and 2023 the spread is wider than usual. Since the corn silage acres are predicted based on this difference, silage acres likely may be overestimated in those years as well. These are additional considerations that will be taken into account for the interpretation of the corn basis forecasting models since this data has some drawbacks.

3.6 Diesel Prices

The diesel price variable was used to represent transportation costs of shipping corn in Southwest Kansas. Since this region is a strong end-user and importer of corn, often from production areas North or East of the region, additional corn is brought in by truck. Ideally, grain trucking rates would be used as the transportation variable, but since that data is often private it

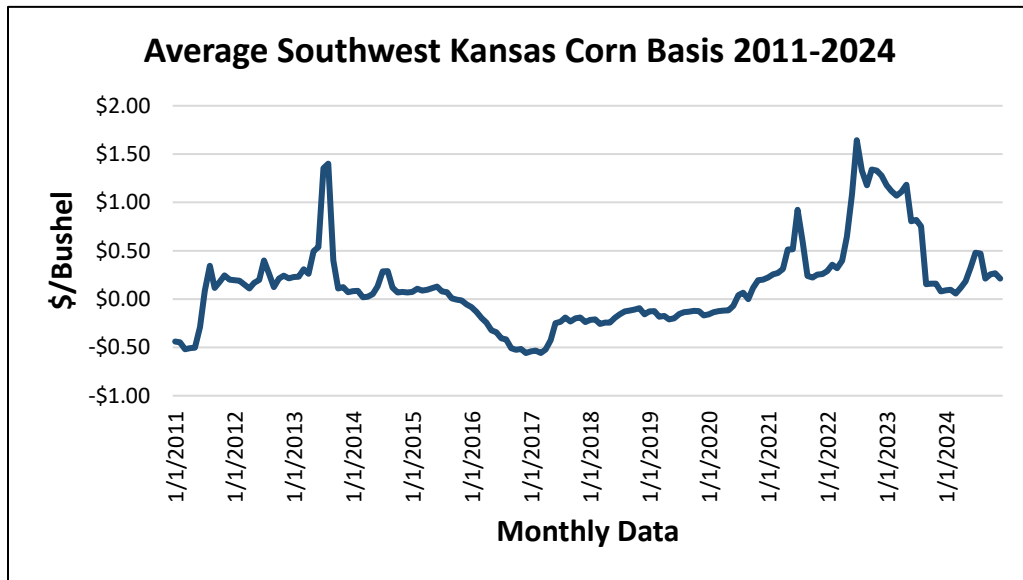
is difficult to acquire. However, diesel prices represent an important portion of trucking rates, so it works well to represent transportation costs. Monthly retail diesel prices were sourced from the U.S. Energy Information Administration (EIA). The type and region the prices derived from were the Midwest and No 2 Diesel Ultra Low Sulfur. This type of diesel is used for all highway transportation, and the Midwest region was the closest match geographically to Southwest Kansas. Figure 3.13. shows monthly diesel prices, and figure 3.14. shows the average Southwest Corn Basis for comparison. As both these figures suggest, the movement of diesel prices and basis does not always move in the same direction, however it does show resemblance occasionally which implies a small potential positive relationship at times.

Figure 3.13. Monthly Diesel Prices Over Time



Source: EIA

Figure 3.14. Representative Average Southwest Kansas Corn Basis Chart

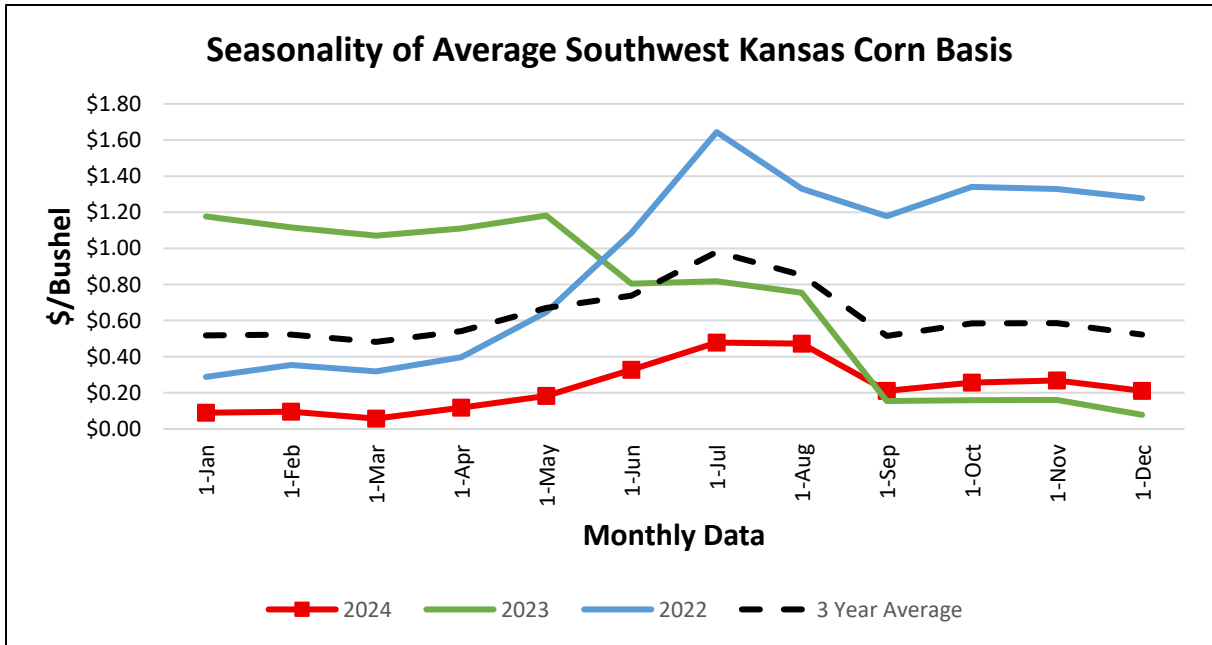


Source: Geograin

3.7 Monthly Dummy Variables

The last independent variables for the data section are dummy variables. Dummy variables are only place holders to capture seasonality of corn basis and do not have any actual data. However, since prior literature indicates corn basis does possess seasonality and economically, we expect when harvest arrives there is a surplus which lowers basis, figure 3.15. illustrates this for the Average Southwest Kansas corn basis. As figure 3.15. suggests there is a pattern of seasonality and it is most noticeable during harvest time for each year. There tends to be a peak in the month of July, then in August and September basis drops lower. Even if the basis has different behavior or is at a different level during the year, it will still follow its seasonal pattern thanks to harvest. Overall, figure 3.15. illustrates the reasoning behind including monthly dummy variables in the corn basis models.

Figure 3.15. Seasonality of Average Southwest Kansas Corn Basis



Source: Geograin

Chapter 4 - Results and Interpretation

To summarize, the findings in the data chapter and the methodology of the corn basis forecasting models are as follows. The time frame of 2015 – 2024 was determined to be the best to account for likely structural change in the region. Proxies determined by linear regression predictions were used to fill in missing values for corn acres planted and corn silage acres harvested. All variables were scaled to monthly, and total cattle inventory, planted corn acres, and corn silage acres, would hold repeating values for each 12 months since they were not monthly variables naturally. The 30 grain elevators in the region originally observed were slimmed down for the forecasting models because many were highly correlated, this was performed to reduce redundancy. Two different types of models were employed; the first set of models are a function of the entire region's explanatory variables. Such region-specific level variables include total cattle inventory, planted corn acres, and corn silage acres. These models would use large and prevalent grain elevators from north, south and the middle of the region to represent corn basis in the area. Then the second set of models observed many individual grain elevators, that utilized their respective county level data for explanatory variables. These models provide value for examining the change in basis at a local level.

4.1 Southwest Kansas Region Models

The first region wide models' results are in table 4.1. Note for these models specifically total cattle inventory, planted corn acres, and corn silage acres all had their units adjusted to every 1 million head, 1 million acres, and 100 thousand acres respectively. This was because the magnitude for these variables is very small. Which economically makes sense because 1 cow or 1 acre is likely to have an inconsequential effect on basis. These variables must be scaled to be

interpreted as large numbers to observe a measurable impact. The number in parentheses under each coefficient value is their standard error.

The R-squares for Alliance Ag at Dodge City, ADM at Montezuma, Scott Coop at Scott City, and Equity Exchange at Liberal all ranged from 0.747 to 0.762. While Garden City Coop at Garden City had the highest R-squared at 0.778 and the average corn basis for the region model's R-square was 0.764. These are interpreted as, for example Garden City's R-Squared of 0.778 rounded up would mean the independent variables of that model explain 78% of the variation in corn basis at Garden City. The RMSE's for these models are high to an extent for basis ranging from 0.249 to 0.268, indicating the magnitude of the errors are \$0.25 – \$0.27/bu. Or these model's ability to forecast basis will have in-sample confidence intervals with standard deviations of \$0.25 - \$0.27. From a high level view these models are valuable with the explanatory variables on average for the models explaining nearly 76% of the variation in basis, however higher RMSEs do have to be noted and taken into consideration when performing further analysis with these models.

The coefficient values and their statistical significance help answer the core questions of this study. They illustrate how the economic factors in this region influence corn basis. Just to clarify, statistical significance at the 1% level equates to a p-value of < 0.01 , statistical significance at the 5% level equates to a p-value of < 0.05 , and statistical significance at the 10% level equates to a p-value < 0.10 . These can also be interpreted as a confidence interval of 99%, 95%, and 90% respectively.

Table 4.1. Regional Corn Basis Models for Southwest Kansas

	<i>Dependent variable:</i>					
	Corn Basis					
	Average Corn Basis for SW KS	Garden City Coop (Garden City)	Alliance Ag (Dodge City)	ADM (Montezuma)	Scott Coop (Scott City)	Equity Exchange (Liberal)
Nearby Corn Futures	0.221*** (0.042)	0.236*** (0.044)	0.246*** (0.044)	0.236*** (0.045)	0.227*** (0.043)	0.231*** (0.045)
Total Cattle Inventory (1M)	0.051 (0.441)	0.035 (0.458)	0.100 (0.465)	0.085 (0.472)	0.022 (0.448)	0.352 (0.474)
Planted Corn Acres (1M)	-0.457*** (0.159)	-0.442*** (0.165)	-0.543*** (0.168)	-0.506*** (0.171)	-0.436*** (0.162)	-0.423** (0.172)
Corn Silage Acres (100k)	0.372*** (0.137)	0.364** (0.142)	0.435*** (0.144)	0.374** (0.146)	0.277** (0.139)	0.315** (0.147)
Diesel Prices	0.113* (0.058)	0.139** (0.060)	0.063 (0.061)	0.121* (0.062)	0.111* (0.059)	0.114* (0.062)
Jan	-0.005 (0.111)	-0.009 (0.116)	-0.017 (0.118)	0.005 (0.120)	0.005 (0.113)	-0.006 (0.120)
Feb	-0.004	0.017	-0.022	0.00002	0.003	0.010

	(0.111)	(0.116)	(0.118)	(0.120)	(0.113)	(0.120)
Mar	-0.058	-0.032	-0.067	-0.068	-0.055	-0.027
	(0.111)	(0.116)	(0.117)	(0.119)	(0.113)	(0.120)
Apr	-0.060	-0.031	-0.075	-0.068	-0.052	-0.019
	(0.112)	(0.116)	(0.118)	(0.120)	(0.114)	(0.120)
May	-0.007	0.017	-0.018	-0.024	0.010	0.025
	(0.112)	(0.116)	(0.118)	(0.120)	(0.113)	(0.120)
Jun	0.102	0.123	0.083	0.081	0.131	0.130
	(0.112)	(0.116)	(0.118)	(0.120)	(0.113)	(0.120)
Jul	0.254**	0.271**	0.276**	0.259**	0.253**	0.302**
	(0.112)	(0.116)	(0.118)	(0.120)	(0.114)	(0.120)
Aug	0.214*	0.237**	0.240**	0.216*	0.197*	0.238*
	(0.112)	(0.116)	(0.118)	(0.120)	(0.114)	(0.121)
Sep	0.029	0.022	0.046	0.018	0.011	0.042
	(0.112)	(0.116)	(0.118)	(0.120)	(0.114)	(0.120)
Oct	0.039	0.053	0.049	0.025	0.031	0.053
	(0.112)	(0.116)	(0.118)	(0.120)	(0.114)	(0.121)
Nov	0.048	0.053	0.064	0.042	0.043	0.078

	(0.112)	(0.116)	(0.118)	(0.120)	(0.114)	(0.120)
Constant	-1.114	-1.193	-1.125	-1.108	-1.065	-1.821*
	(0.943)	(0.979)	(0.995)	(1.011)	(0.959)	(1.015)
Observations	120	120	120	120	120	120
R ²	0.764	0.778	0.752	0.762	0.747	0.756
Adjusted R ²	0.728	0.744	0.714	0.725	0.707	0.718
Residual Std. Error (df = 103)	0.249	0.259	0.263	0.267	0.253	0.268
F Statistic (df = 16; 103)	20.860***	22.572***	19.546***	20.562***	18.989***	19.900***

Note: Standard errors are in parentheses

*denotes significance at the 10% level

**denotes significance at the 5% level

***denotes significance at the 1% level

The nearby corn futures coefficients have a positive sign with all the models varying between 0.221 to 0.246. They are also all strongly statistically significant at the 1% level, this meets expectations and indicates corn futures does play a significant role in explaining corn basis. The interpretation for this coefficient equates to if corn futures rise by 1 dollar per bushel, then basis is expected to increase by \$0.25/bu. for example.

Total cattle inventory's coefficient ranged from 0.022 to 0.10 for all elevators except Liberal at 0.35. All the Elevator's p-values were also particularly not close to statistical significance with the lowest at 0.46 for Liberal. The signs matched expectations, however the statistical significance of all the variables did not. Since the total cattle inventory variable was scaled to a million head, this magnitude can be interpreted for example as if 1 million more cattle are raised in the region, then basis will result in a \$0.35/bu. increase. The magnitudes would have intuitively been expected to be higher, as well as statistical significance, but the signs still match expectations that cattle inventory and basis would have a positive relationship.

The corn planted acres coefficient had a negative sign for each model and a range of -0.423 to -0.543. These coefficients were all statistically significant at the 1% level besides Liberal, and it was significant at the 5% level. This matches expectations along with the expected sign and the coefficients had reasonable magnitudes as well. This logically, makes sense because when there are more corn acres in the region, this leads to a greater supply of corn, which results in corn basis decreasing. Similar to the cattle inventory variable, planted corn acres are scaled as a million acres, so it can be interpreted for example as if planted corn acres in the region increase by 1 million, then corn basis will decrease by \$0.54/bu.

For the corn silage acres variable, the coefficients ranged from 0.277 to 0.435. The sign matches expectations and the magnitudes are slightly greater than what may have been

anticipated. All variables were statistically significant at the 5% level, and two were statistically significant at the 1% level. This variable was scaled at 100 thousand acres instead, so it can be interpreted as if there is an increase in corn silage acres by 100 thousand acres, then corn basis will increase by \$0.44/bu.

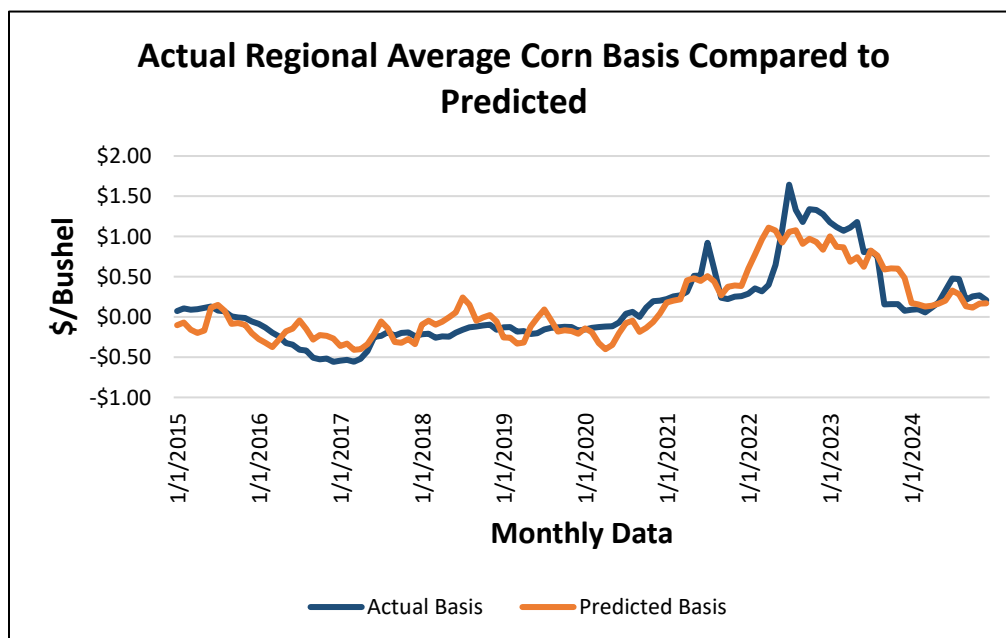
For the diesel prices variable, the coefficients ranged from 0.063 to 0.139. Garden City had the only variable, statistically significant at the 5% while the remaining were statistically significant at the 10% level except for Dodge City, which had a p-value of 0.31. The sign meets expectations and the magnitude economically is justifiable as well. Diesel Prices were not scaled in any way so they can be interpreted for example as a dollar increase in diesel prices per gallon will result in basis increasing by \$0.14/bu.

Lastly, the monthly dummy variable coefficients can be interpreted as in comparison to the month of December since it is the month that is dropped. It also is just simply how many units more or less basis is in comparison to basis in December. All the months except for July and August were not statistically significance. All the models' months of July were statistically significant at the 5% level. While all the models' month of August were statistically significant at the 10% level except for Garden City and Dodge City, which were significant at the 5% level. Both these months had coefficient values ranging from 0.197 to 0.302, with the month of July showcasing higher values than the month of August. This intuitively makes sense compared to the month of December. We can expect July to have higher basis levels in comparison, and August to not be as high as July but still be higher than December as well. What did not match expectations were the months of September, October, or November to not have greater statistical significance sense these are harvest months as well. Additionally, under the original assumption,

July was not a harvest month, and neither was August even though harvest can start towards the end of it. So, these results are intriguing that July and August have more explanatory power.

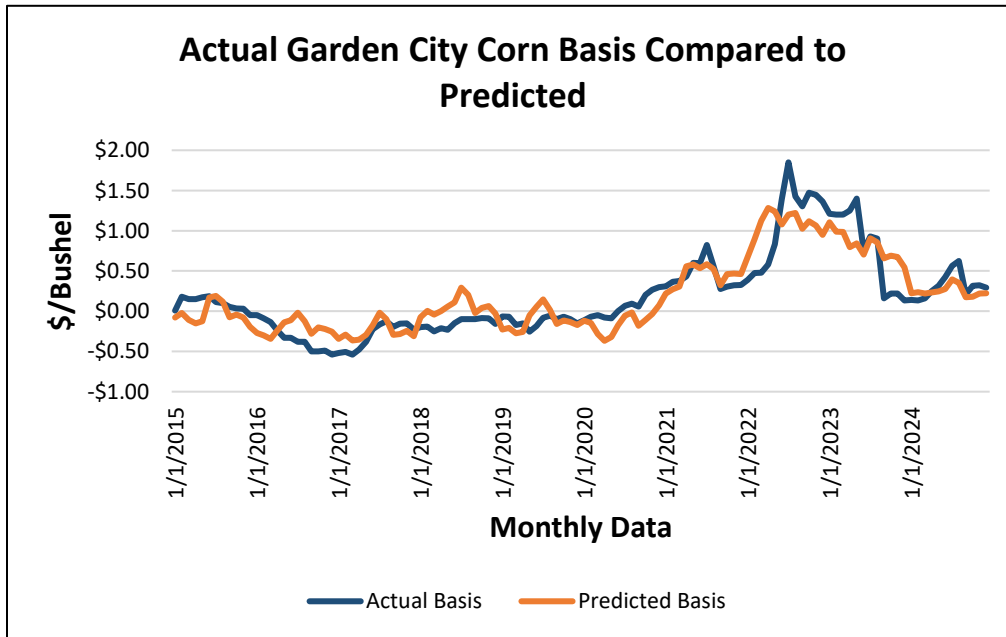
Figure 4.1. and 4.2. illustrate the predicted vs actual values for the average representative corn basis model and the Garden City model respectively since they had the highest R squares. It illustrates the accuracy of these models and can explain the RMSEs since it is clear that there can be wider gaps occasionally between the actual and predicted values.

Figure 4.1. Actual Regional Average Corn Basis Compared to Predicted



Source: Geograin

Figure 4.2. Actual Garden City Corn Basis Compared to Predicted



Source: Geograin

4.2 Individual Elevator Models

The individual grain elevator models' results are table 4.2. Note similarly to the region wide models total cattle inventory, planted corn acres, and corn silage acres units were all adjusted as well because of the small magnitudes in comparison. For these, since the data is county level and not the entire region of Southwest Kansas the adjustments are not as large, they are as follows. Total cattle inventory 100 thousand, planted corn acres 100 thousand, and corn silage acres 10 thousand. So, for each of those variables to have the impact on basis the coefficients in the table represent, cattle inventory must increase by 100 thousand in the county, planted corn acres must increase by 100 thousand, and corn silage acres must increase by 10 thousand. Table 4.2. is also in similar format to table 4.1. Since these models are similar to the

first group of models and just provide additional granularity, the following paragraph will be high level points for these models.

The R-squared of all the models ranged from 0.688 to 0.797 with RMSEs ranging from 0.249 to 0.286. Nearby corn futures coefficients were all statistically significant at the 1% level. Total cattle inventory coefficients were mixed, with Larned, Elkhart, and Meade with negative signs which economically do not meet our assumptions. Elkhart and Meade were not statistically significant however Larned was at the 1% level. For the remaining coefficients that had positive signs, 5 were statistically significant at the 10% level, and 4 were not statistically significant. For the planted corn acres variable, all coefficients had a negative sign as expected except for Larned and it was not statistically significant. Three grain elevators were statistically significant at the 1% level, three held significance at the 5% level, and three were significant at the 10% level. The corn silage acres variable had 6 of the coefficients with a negative sign which does not match expectations, while 6 had a positive sign. Three of the negative coefficient variables were statistically significant at the 5% level and one was significant at the 1% level. The remaining two negative coefficients had p-values above 0.70. For the coefficients with positive signs, one was significant at the 10% level, 2 were significant at the 5% level, and 2 were significant at the 1% level. The diesel prices variable was consistent, and all had the same positive sign, which matches expectations. One coefficient was statistically significant at the 10% level, and nine were all significant at the 1% level. Meade's coefficient was just shy of statistical significance at the 10% level and Ness City had a p-value of 0.78. Lastly, for the monthly dummy variables, like the previous models, only the months of July and August would have coefficients with statistical significance and they would have positive signs. Similarly, the month of July's coefficients tended to have a larger magnitude than the month of August's.

Table 4.2. Individual Grain Elevator Corn Basis Models For Southwest Kansas

	<i>Dependent variable:</i>											
	Corn Basis											
	CHS (Tribune)	Scott Coop (Scott City)	DE Bondurant Grain (Ness City)	Skyland (Syracuse)	Garden City Coop (Garden City)	Pawnee County Coop (Larned)	ADM (Montezuma)	Alliance Ag (Dodge City)	Offerle Coop (Bucklin)	Elkhart Coop (Rolla)	Equity Exchange (Liberal)	Meade Coop (Meade)
Nearby Corn Futures	0.181*** (0.053)	0.189*** (0.037)	0.151*** (0.038)	0.207*** (0.038)	0.165*** (0.040)	0.140*** (0.041)	0.162*** (0.041)	0.202*** (0.041)	0.135*** (0.039)	0.207*** (0.033)	0.214*** (0.044)	0.287*** (0.043)
Total Cattle Inventory (100k)	4.482 (3.130)	0.453** (0.221)	4.264*** (0.730)	1.074* (0.605)	0.367** (0.167)	-1.150*** (0.406)	0.025 (0.213)	0.398 (0.241)	0.407* (0.229)	-0.361 (0.851)	0.280 (0.272)	-0.287 (0.343)
Planted Corn Acres (100k)	-0.791* (0.467)	-0.597*** (0.204)	-1.248** (0.489)	-1.876*** (0.516)	-0.302*** (0.094)	0.123 (0.390)	-0.373 (0.328)	-1.292* (0.757)	-1.243* (0.718)	-0.744** (0.307)	-0.877** (0.405)	-0.032 (0.633)
Corn Silage Acres (10k)	-0.102 (0.359)	0.001 (0.056)	2.485*** (0.829)	0.339** (0.134)	-0.162** (0.071)	0.396** (0.169)	-0.441*** (0.140)	-0.882** (0.402)	-0.950** (0.381)	0.741* (0.427)	-0.064 (0.189)	0.629*** (0.221)
Diesel Prices	0.239*** (0.055)	0.155*** (0.051)	0.019 (0.069)	0.263*** (0.055)	0.233*** (0.054)	0.120* (0.061)	0.300*** (0.063)	0.197*** (0.068)	0.248*** (0.064)	0.207*** (0.048)	0.185*** (0.060)	0.094 (0.057)
Jan	-0.001	0.009	-0.136	0.036	0.0003	-0.020	0.022	-0.004	-0.002	-0.001	0.001	0.0005

	(0.128)	(0.114)	(0.114)	(0.121)	(0.116)	(0.121)	(0.121)	(0.124)	(0.117)	(0.111)	(0.123)	(0.124)
Feb	-0.009	0.008	-0.103	0.047	0.027	-0.032	0.017	-0.010	-0.009	0.024	0.016	-0.007
	(0.128)	(0.114)	(0.114)	(0.121)	(0.116)	(0.121)	(0.121)	(0.124)	(0.117)	(0.111)	(0.123)	(0.124)
Mar	-0.106	-0.054	-0.108	-0.014	-0.029	-0.081	-0.068	-0.067	-0.063	-0.043	-0.028	-0.075
	(0.128)	(0.114)	(0.114)	(0.121)	(0.116)	(0.121)	(0.121)	(0.123)	(0.117)	(0.111)	(0.123)	(0.124)
Apr	-0.076	-0.044	-0.171	-0.003	-0.016	-0.121	-0.053	-0.066	-0.063	-0.035	-0.016	-0.095
	(0.129)	(0.115)	(0.114)	(0.121)	(0.116)	(0.122)	(0.121)	(0.124)	(0.117)	(0.111)	(0.123)	(0.125)
May	-0.031	0.016	-0.180	0.048	0.027	-0.044	-0.018	-0.015	-0.016	0.045	0.025	-0.031
	(0.128)	(0.114)	(0.114)	(0.121)	(0.116)	(0.121)	(0.121)	(0.124)	(0.117)	(0.111)	(0.123)	(0.124)
Jun	0.131	0.126	-0.136	0.167	0.112	0.070	0.063	0.071	0.058	0.139	0.124	0.052
	(0.128)	(0.114)	(0.114)	(0.121)	(0.116)	(0.121)	(0.121)	(0.124)	(0.117)	(0.111)	(0.123)	(0.124)
Jul	0.239*	0.243**	-0.168	0.324***	0.250**	0.235*	0.232*	0.259**	0.184	0.262**	0.294**	0.245*
	(0.129)	(0.115)	(0.114)	(0.121)	(0.116)	(0.122)	(0.121)	(0.124)	(0.118)	(0.112)	(0.124)	(0.125)
Aug	0.178	0.184	-0.151	0.222*	0.213*	0.211*	0.187	0.222*	0.180	0.220*	0.230*	0.241*
	(0.129)	(0.115)	(0.115)	(0.122)	(0.117)	(0.122)	(0.122)	(0.124)	(0.118)	(0.112)	(0.124)	(0.125)
Sep	-0.010	0.001	-0.129	0.031	0.002	0.061	-0.009	0.028	0.019	0.027	0.034	0.038
	(0.129)	(0.115)	(0.114)	(0.121)	(0.116)	(0.122)	(0.121)	(0.124)	(0.118)	(0.112)	(0.124)	(0.125)
Oct	0.021	0.020	-0.125	0.022	0.029	0.031	-0.012	0.022	-0.009	0.030	0.040	0.053
	(0.129)	(0.115)	(0.115)	(0.122)	(0.117)	(0.122)	(0.122)	(0.124)	(0.118)	(0.112)	(0.124)	(0.125)
Nov	0.032	0.033	0.006	0.031	0.033	0.036	0.010	0.042	-0.002	0.046	0.067	0.056
	(0.129)	(0.115)	(0.114)	(0.121)	(0.116)	(0.122)	(0.121)	(0.124)	(0.118)	(0.112)	(0.124)	(0.125)

Constant	-2.711*** (0.705)	-2.089*** (0.376)	-2.094*** (0.189)	-2.770*** (0.741)	-1.739*** (0.349)	-0.302 (0.413)	-0.896 (0.607)	-1.189** (0.548)	-1.139** (0.520)	-1.206*** (0.300)	-0.944*** (0.329)	-1.415** (0.581)
Observations	120	120	120	120	120	120	120	120	120	120	120	120
R ²	0.745	0.742	0.719	0.747	0.777	0.688	0.756	0.726	0.709	0.797	0.742	0.711
Adjusted R ²	0.705	0.702	0.675	0.708	0.742	0.640	0.718	0.684	0.664	0.766	0.702	0.666
Residual Std. Error (df = 103)	0.286	0.256	0.255	0.270	0.259	0.271	0.270	0.276	0.262	0.249	0.275	0.278
F Statistic (df = 16; 103)	18.796***	18.526***	16.444***	18.992***	22.438***	14.216***	19.950***	17.082***	15.691***	25.297***	18.533***	15.800***

Note: Standard errors are in parentheses

*denotes significance at the 10% level

**denotes significance at the 5% level

***denotes significance at the 1% level

Chapter 5 - Discussion and Conclusion

The results of this study provide several notable insights that are worth discussing. All the models provide respectable R-squares, and overall, the independent variables explained the variation in corn basis well. The RMSEs were higher than ideal for grain basis; however, as prior literature highlighted, increased volatility in the grain markets in recent years may be a reality that adversely affects forecasting. There could be other improvements to the models as well, such as potentially incorporating other variables that are unaccounted for or implementing data with greater accuracy, which could lower RMSEs. However, acquiring alternative data for a small, specific region such as southwest Kansas can be difficult.

Most of the independent variables throughout the models did hold varying statistical significance. They also, on average, matched the initial expectations in signs and had reasonable magnitudes. A few expressed some key takeaways, however. This includes total cattle inventory; interestingly, the regional model's variables were not statistically significant and had low magnitudes. While for the county level models, cattle inventory would have varying degrees of significance and had higher magnitudes across the board in comparison. This could indicate on a regional level; cattle inventory isn't as impactful in explaining basis compared to more localized county effects. The corn silage acres coefficients consistently had strong magnitudes, and all had statistical significance for the regional models. This suggests the assumption that southwest Kansas's silage production is sizable enough to have an impact on total corn for grain supply. Lastly, the diesel prices coefficients tended to be greater for towns that were in counties with high cattle inventories. This supports the assumption that counties that require more corn will post stronger basis bids to ensure demand is met even when transportation costs are higher. For the individual elevator models, the magnitudes for the diesel price were even higher.

The results from these models can be used for potential projections for the anticipated changes that are to occur in southwest Kansas. As previously discussed, with the expansion of the dairy industry in the region, there may be a greater than 2-fold growth in total dairy cattle. With the confirmed capacity of the Himar Cheese processing facility in Dodge City at 110,000 head, a growth of this magnitude in the region will have an impact on corn basis. Additionally, the new feedlot expansion of 88,000 that was discussed will also have an impact but likely it will be in a few more years before the site has reached its full capacity. For the analysis of a projection, one of the regional models was selected to be interpreted as the expected effect on corn basis for the region. One drawback of this projection is that the total cattle inventory coefficients are not statistically significant. So, the model that had the lowest p-value was selected, which was the regional model utilizing Equity Exchange at Liberal. The total cattle inventory's coefficient was 0.35, meaning if cattle inventory in the region rose by 1 million head, corn basis would rise by \$0.35/bu. Moreover, for the projection, the amount of silage acres required to fulfill the feed needs of the dairy cows was also examined for its effect on basis. As priorly examined, depending on milk production per cow and feed formulations, the total amount of silage required for dairy cows can vary widely. Lastly, a change in corn acres was also investigated to see what its effect is. Corn acres year over year can be quite volatile and as cited with ground water concerns in the region, corn acres may decrease in the long run. Tables 5.1., 5.2., and 5.3. illustrate outcomes for what the basis changes could be.

Table 0.1. Impact on Southwest Kansas Basis by Varying Changes in Corn Acres Planted

Impact on Southwest Kansas Basis by Varying Changes in Corn Acres Planted *Using Equity Exchange Liberal Model		
Percent Change in Corn Acres Planted	Increase in Acres	Decrease in Acres
+/- 10%	-\$0.06	\$0.06
+/- 20%	-\$0.12	\$0.12
+/- 40%	-\$0.24	\$0.24

**Table 0.2. Impact Scenario on Southwest Kansas Basis with 110,000 Head Increase In
Total Cattle Inventory**

Impact on Southwest Kansas Basis with 110,000 Head Increase in Cattle *Using Equity Exchange Liberal Model			
Increase in Silage Acres	35,000	70,000	105,000
Silage Acres Basis Impact	\$0.11	\$0.22	\$0.33
Cattle Inventory Basis Impact	\$0.04	\$0.04	\$0.04
Silage and Cattle Basis Impact	\$0.15	\$0.26	\$0.37
Total Basis Impact with +10% in Corn Acres Planted	\$0.09	\$0.20	\$0.31
Total Basis Impact with -10% in Corn Acres Planted	\$0.21	\$0.32	\$0.43

Table 0.3. Impact Scenario on Southwest Kansas Basis with 198,000 Head Increase in Total Cattle Inventory

Impact on Southwest Kansas Basis with 198,000 Head Increase in Cattle *Using Equity Exchange Liberal Model			
Increase in Silage Acres	35,000	70,000	105,000
Silage Acres Basis Impact	\$0.11	\$0.22	\$0.33
Cattle Inventory Basis Impact	\$0.07	\$0.07	\$0.07
Silage and Cattle Basis Impact	\$0.18	\$0.29	\$0.40
Total Basis Impact with +10% in Corn Acres Planted	\$0.12	\$0.23	\$0.34
Total Basis Impact with -10% in Corn Acres Planted	\$0.24	\$0.35	\$0.46

Table 5.1. illustrates the varying impacts of basis with different percentage changes in total corn acres planted. All percentages are based on the year 2024's corn acres. The larger percent changes are to illustrate scenarios if corn acres were to significantly decrease in the future due to groundwater availability issues. To provide context, the 10% change in 2024 was close to 150,000 acres with an impact of \$0.06/bu. on basis. This impact, especially compared to the silage acres' impact on basis seems low; however, this is just a consideration to note for these examples. Silage acres had impacts of \$0.13, \$0.25, and \$0.38 on basis, for increases in silage acres by 35,000, 70,000, and 105,000 acres, respectively. These varying changes in silage acres are what could be realized to meet the demand for 105,000 more dairy cows, depending on the feed formulations used by the dairies in the region. Cattle inventory basis impact was comparatively lower, with an impact of \$0.04 and \$0.07 for an increase of 110,000 and 198,000 head, respectively. Again, these two numbers are what could be realized in the future, with the first, for needs of dairy demand, and then the second, with the addition of cattle for the new

feedlot that will be built along with the dairy cattle expansion. Tables 5.2. and 5.3. showcase both of these scenarios, the total impact of both the silage acres and the increase in total cattle inventory added together, and lastly, what the impact would be, along with a 10% change in total corn acres in both directions. The 10% change in corn acres in both directions is to show what the impact could be with given standard volatility in total corn acres planted, and a 10% change year over year is consistent with past behavior.

Overall, in 1 to 2 years, just from the increase in dairy cattle, we could exhibit basis in the region to strengthen between just \$0.09/bu. and \$0.43/bu., given the exact scenario. While in another 1-2 years on top of that, once the feedlot is in place, basis could strengthen by another few cents. The impact on basis from cattle inventory and corn acres planted may seem to be low in comparison to silage acres, which intuitively does not make total sense at first glance. However, silage acres may be capturing some of the explanatory power of both those coefficients. Part of why total cattle inventory strengthens basis is because of the silage acres they demand; moreover, silage acres can be the direct impact of less corn for grain as well. These aren't perfect explanations behind the magnitude of silage acres being larger in comparison; however, it can help explain part of the reasoning. Altogether, these projections are helpful and valuable, but just like all economic models, all outcomes can never be projected with complete accuracy, and some may have minor flaws.

Lastly, an additional consideration for the results and especially given the time series nature of these models is to address the potential concern for autocorrelation. Autocorrelation is when the model's residuals over time are correlated. Autocorrelation can inflate t-statistics since the standard errors are smaller than they should be. This could produce inaccurate p-values which may be interpreted as statistically significant when realistically they are not. If

autocorrelation occurs, the OLS estimators remain linear and unbiased however they are no longer the “best” or most efficient estimator which yields a more cautious result for statistical significance. To test for autocorrelation, a Durbin-Watson test was conducted for each of the regional based models since these were the main models for the analysis. Each model’s Durbin-Watson test produced similar results which non-ideally indicated evidence for positive autocorrelation. For example, the Regional Average Corn Basis model resulted in a DW statistic of 0.37 and a p-value less than 0.001 and the Regional Equity Exchange model produced a DW statistic of 0.43 and a p-value less than 0.001. The interpretation for the Durbin-Watson test is as follows, if the DW statistic is close to 2 then there is no strong autocorrelation, if it is close to 0 then there is strong autocorrelation, and lastly if it is close to 4 then there is strong negative autocorrelation. Since the DW for all the regional based models were below 2 and closer to 0 along with a p-value close to zero the test’s outcome is to reject the null hypothesis of no autocorrelation. This unfortunately adds another drawback to the study when interpreting statistical significance and is a consideration to be aware of for the projection analysis as well. Moreover, this could potentially be another reason behind the corn silage coefficient’s higher statistical significance compared to total cattle inventory for example.

Moreover, there are a few limitations to highlight as well as further improvements that could be added or built upon this study. Limitations include the proxies that had to be made for some of the missing basis values, missing counties in some years for corn acres planted, and all the silage acres being estimated besides the years Census values were available. This is just a data availability issue and likely, it is difficult to obtain a full and clean data set for all these variables. Additionally, there are not many alternative sources to obtain basis data, and they likely will not always be complete and have the detail of daily data. Moreover, the missing

values from USDA NASS could potentially be acquired through confidentiality agreements, but it is not guaranteed, and it could be a time-consuming process. For the most part, the data used for this study was the best that could be acquired. Additionally for data variables it would have been more appropriate to use cattle on feed instead of cattle inventory, and a grain trucking rate instead of diesel prices, as well, for the models. Potentially even a dairy cow's inventory in addition to the variables, too; however, data sets for these specific descriptions were not available on a granular and region-specific level at USDA NASS, and trucking rate data is private information. Lastly, the nature of these models also has some aggregate issues for the data. Corn acres planted and corn silage acres are only annual values, while these models are based on monthly data. Cattle inventory was also only available on an annual basis on January 1st from USDA NASS. These variables may not provide the most accurate coefficient values because of the disconnect between monthly and annual data. This also may be a reason behind the Durbin-Watson test results of autocorrelation as well. Changes to the type of data and further model adjustments to the data could have been made to reduce or eliminate autocorrelation, however the results still provide magnitudes, directional outcomes for analysis, as well as foundational work to this specific area of study.

Further improvements and areas where this study could be built upon involve a few different directions. The relationship of pricing in the region could be explored further beyond correlations of basis values, and price leadership in the area could have been studied. Concerns over the Ogallala Aquifer were addressed; however, a more in-depth exploration of the topic and specific planting trends for the future could be explored. Potentially, certain counties or smaller areas in the Southwest region that are known to have groundwater concerns could be examined to see what production may look like in the future and how that could affect the total supply of

corn in the region. Expanding the region to include another area in Kansas with dense livestock production, such as South-Central Kansas, or a comparative analysis between the two regions could also provide value. Lastly, this type of model could also be applied to other areas where livestock and dairy production is strong to examine how they influence corn basis in their respective regions. This could be in areas such as Nebraska, Texas, and potentially areas in California where corn silage usage is high for dairy demand.

The conclusion of this study holds several different remarks. The relationship between grain elevators' corn basis in the region suggests an efficient market and tightly related corn pricing in the region. Examining individual elevators in the region also highlighted that the majority of the elevators' basis can be explained by the same local variables. This highlights the strong impact local supply and demand factors have on corn pricing for the region. Moreover, the main takeaway of the study includes that immediate livestock expansion in southwest Kansas is occurring, along with potential long-term supply of corn decreasing due to water constraints. It will be important for producers and grain merchants to anticipate the immediate impacts on corn basis in the short run and what could happen in the long run. The increasing livestock demand will have an immediate impact on basis in the region and depending on how exactly the other factors that influence basis change, the result can vary widely. A median result due to the increase in beef cows, dairy cows, and the resulting silage acres from the change could be an increase in basis by \$0.29/bu. for the region. This is a significant change for all parties in the grain business, producers, and end-users. There may be limitations to the accuracy of the models employed in this study however, just like many econometric modeling studies 100% accuracy is likely never obtainable. This study does, however, provide valuable insights into agriculture in

the region, and a data-driven prediction that provides a range of how corn basis will be impacted in the future.

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