

**Analysis of factors impacting corn grain basis
values in Western Kansas**

by

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ABSTRACT

Through the advancements of technology and demand, corn has become a foundational production crop for western Kansas producers. However, along with growth in corn production, corn price volatility also seems to be increasing at an increasing rate – especially since the growth in corn ethanol use began in earnest in 2006. The goal and scope of this study is to analyze variables impacting the local basis part of the cash grain pricing mechanism in Western Kansas. Variables considered in this study include historical weekly cash corn basis values, future values, price seasonality trends, the impact of ethanol biofuel corn usage, and state and national corn stock values. The geographical scope of the study is focused on Western Kansas, focusing on two key grain market locations, i.e., the Garden City Co-op in Garden City, in southwest Kansas, and Cornerstone Ag, LLC in Colby, in northwest Kansas.

This study uses linear regression forecasting models to analyze and project the impact of key factors on corn basis levels. The data consists of weekly independent explanatory variables described above for marketing years from 2000 – 2022. The results of this model display the differing seasonality impacts, for both locations, along with market leadership for the Garden City grain markets in southwest Kansas in comparison to grain markets in Colby in northwest Kansas. Marketing years 2021/22 – 2021/22 were forecasted out-of-sample for both locations with known basis values to observe the accuracy of the model in comparison to historical five-year average basis values. These results determined that the lagged basis value from the previous week provides greater

accuracy in determining the expected basis value for the next following week in comparison to historical five-year average basis values.

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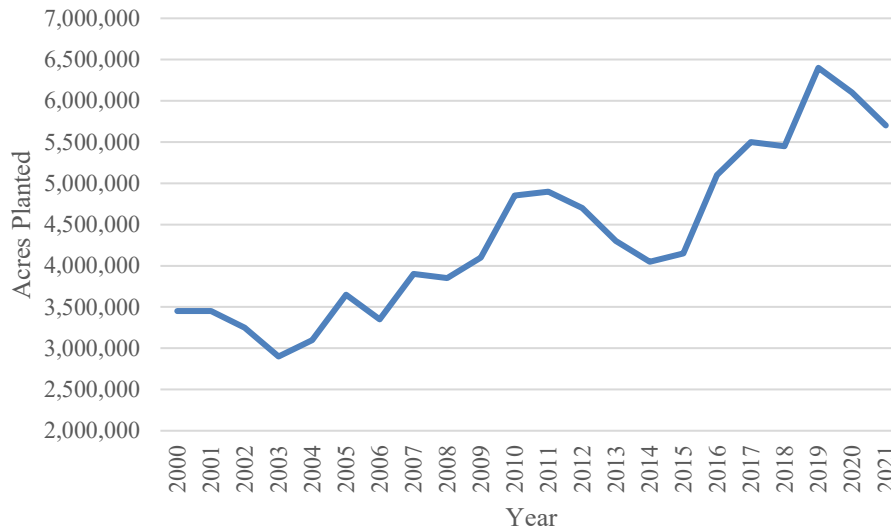
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CHAPTER I: INTRODUCTION

Throughout the last 20 years, “The Corn Belt” has continued to grow west. This has been made possible by technology advancements in genetically modified corn seed. These advancements along with sustainable farming practices—like no-till—have allowed corn to compete for acres across Kansas. The state of Kansas corn acres has grown significantly over this time period. This has also been driven by supply and demand shifts for corn throughout Western Kansas. From 2000 to 2021, Kansas corn acres have risen 65% (Figure 1.1). Kansas corn acres grew from 3.45 million acres to 5.7 million acres in 2021, along with a state high in acres planted in 2019 of 6.4 million (National Agricultural Statistics Services n.d.).

Figure 1.1: Planted Corn Acres in Kansas



Two of the largest demand factors throughout the state of Kansas are cattle on feed and the expansion of ethanol plants. The expansion of ethanol plants happened after the 2005 Renewable Fuel Standards Act. The goal of the Renewable Fuel Standards act was to reduce greenhouse gas emissions by producing alternative bio-fuels. These large demand

factors, along with an increasing supply of corn, have altered cash corn prices throughout Kansas.

Cash corn prices are driven by two factors: futures prices set by the Chicago Board of Trade and local basis. The function and purpose of local basis is to account for the cost of transportation and the impacts of local supply and demand across specific commercial grain industry locations within a region. Grain basis varies throughout the United States in diverse grain markets, being an indicator of local demand for the specific grain commodity by location. Areas with stronger demand relative to available supply of the specific commodity have a stronger basis, and vice versa. Through improvements of transportation and the increased access to local grain market information the volatility of corn basis bids has increased over time. This has been observed with corn basis data collected for this study provided from www.AgManager.info for the Colby and Garden City locations.

The main client regarding this thesis work is Frahm Farmland Inc. This is the organization the author is employed with. Frahm Farmland is a corn and wheat producer in Northwest Kansas, having their own grain handling facility. This on farm facility holds 3.7 million bushels of grain, and it operates year-round. This grain facility is used for storage of both corn and wheat production, but 90% of the storage is used for corn. Frahm Farmland realizes the tremendous value created by their grain facility through the ability to capitalize on the logistical grain handling and storage-related opportunities that they provide. These market opportunities involve and benefit from the flexibility provided in the ability to set and/or manage local grain basis. The organization is managing basis risk through hedging futures contracts and basis contracts. Frahm Farmland as an organization desires to further

understand the impacts of Kansas corn production trends from a macro level on current and future local (and regional) basis bids for corn.

As the items above have changed over time, this has increased the importance of further understanding how these shifts have altered corn basis along with the seasonality of Western Kansas corn market price trends. The purpose of this thesis is to analyze the factors that determine corn basis in Western Kansas, considering past basis trends, corn market supply and demand variables, and other factors. A regression analysis that utilizes a nesting function process will be used in this analysis. The process of nesting explanatory variables within the basis determination function will provide the ability to add sequential explanatory data to be considered in consecutive, related grain basis models.

The geographic scope of this study is Western Kansas. This geographic location is the first supply and demand factor considered. The primary focus of this study is on two leading Western Kansas corn market locations. The first of two locations used for corn basis data is Garden City Coop—a grain elevator in Garden City, Kansas. The Garden City, Kansas corn market represents possibly the most predominant basis reference location in Western Kansas, being located in Southwest Kansas, the state's leading livestock feeding and ethanol production region.

The second key corn market location used in this model for corn basis data will be in Colby, Kansas, specifically focusing on Cornerstone Ag, LLC – a grain elevator located in Northwest Kansas. This location was selected to represent the key reference location of Frahm Farmland Inc., also located near Colby, Kansas. Frahm Farmland Inc. is associated via employment with the author of this study.

The Garden City cash grain market in Southwest Kansas is a key reference point for the Colby cash grain market in Northwest Kansas. The transportation differential and differing regional feed grain supply and demand factors are expected to determine any grain price and basis differences between the two locations at any point and time. The distance between the two locations is 106 miles. Looking at the supply chain of this model the grain market in Colby is located “upstream” from the corn demand centers located “downstream” in Southwest Kansas near Garden City. Grain is generally transported from upstream to downstream locations in this region by truck transportation. Although both locations have rail access to import and export grains within the state of Kansas, the economics of truck versus rail transportation dictate the use of trucks to move grain from Colby in Northwest Kansas to the Garden City area in the Southwest part of the state.

The primary objective of this thesis is to have an understanding of factors affecting the local and regional movement of grain in regards to on farm grain storage for the western Kansas producer. For instance, www.agmanager.com tracks historical basis bids for grain elevators throughout the state. This is a great tool to understand trends and cycles of corn basis, but it is not necessarily a direct reflection of on farm grain basis bids. Frahm Farmland has observed there is a large variation between publicly listed local grain elevator basis bids and bids received by farm operations having on farm storage. The spread between these two figures is not a constant variable, but the direction and movement of the commercial elevator bids still have a very strong correlation with on farm basis bids. The results of this thesis work will provide a more in depth understanding of the movement in corn basis at the commercial elevator level. At the end of this study, the goal for Frahm Farmland is that what is learned from this study will be helpful in making more informed

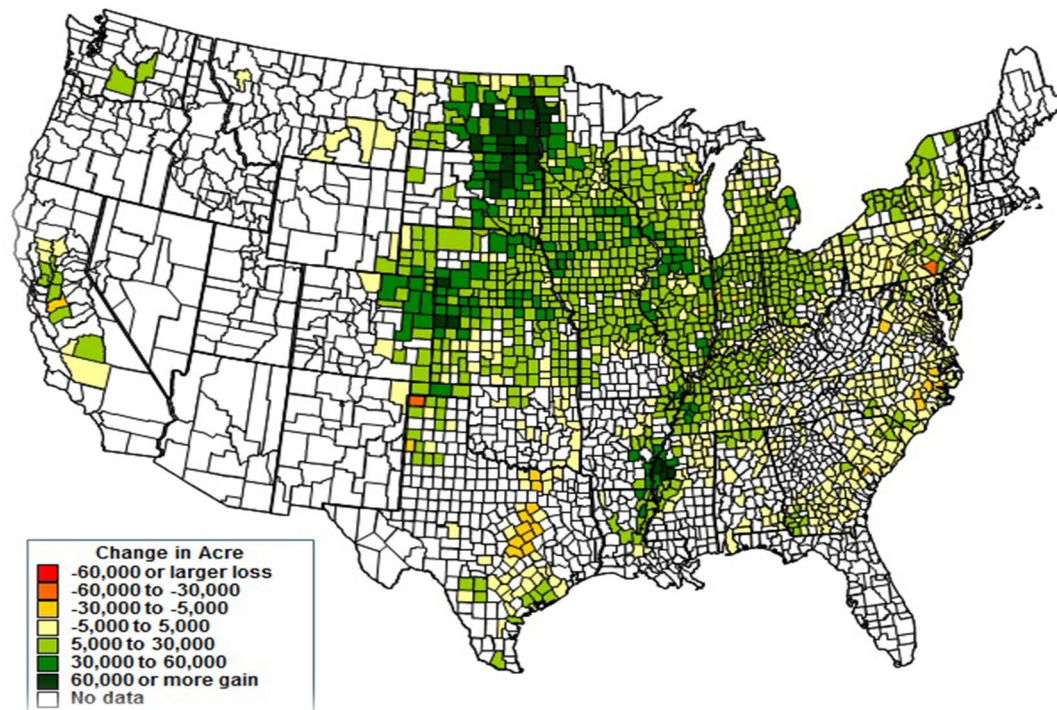
grain marketing decisions based on a more in-depth understanding of the driving factors impacting corn basis in Western Kansas for commercial elevators and farms in the region.

CHAPTER II: LITERATURE REVIEW

In preparation for this study there were not comparable studies of logistical differences in grain basis across demand locations. However, there were a number of studies relevant to grain basis issues across space, time, and local grain market leadership.

The shift in corn acres as stated above is one of the largest variables affecting grain prices in Western Kansas. Figure 1.1 above displays the increasing acres of corn planted in the state of Kansas. Figure 2.1 was provided by Gary Schnitkey from the University of Illinois Department of Agricultural and Consumer Economics. This figure demonstrates how strong of an acre shift Western Kansas experienced during the 2006 to 2012 period. This shift is the second strongest nationwide throughout this time period next to eastern North and South Dakota. The acre shift is in response to profitability in producing corn. This was seen from a combination of high grain prices which were partially influenced by supply issues along with the ethanol boom after the 2005 Renewable Fuel Standards Act. During the 2006 to 2012 time period corn acres increased from 78 million acres to 97 million acres, a 24 percent increase (Schnitkey 2013).

Figure 2.1 Change in Corn Acres by County from 2006 to 2012 (Schnitkey 2013).



The U.S. Renewable Fuel Standards act was beneficial for U.S. grain farmers. The 2005 Renewable Fuel Standards act began by requiring blending of 7.5 billion gallons of renewable fuel with gasoline annually by the year 2012. Following the RFS Act of 2005 was the Energy Independence and Security act of 2007. This act set a target of 36 billion gallons of blended renewable fuels to be produced annually by 2022, including both domestic and imported biofuels (Condon, Klemick and Wolverton 2013).

The energy policy acts stated above resulted in major expansion in the ethanol industry. In 2005 there were 81 ethanol plants in the United States blending 3.9 billion gallons. By 2012 the United States had built up to 209 ethanol plants, blending 13.22 billion gallons of ethanol per year. After 2012, the number of ethanol plants in the United States remained relatively flat, eventually ending up in a slight downturn of 201 ethanol

plants in 2020, with production of ethanol ranging from 13.2 to 16.06 billion gallons of ethanol per year (The U.S. Department of Energy 2021).

For every additional billion gallons of ethanol produced, a 2 to 3 percent increase in long-run corn prices is observed on average (Condon, Klemick and Wolverton 2013). This price flexibility measurement is very straightforward from an economics perspective *ceteris paribus*. In addition, other outside annual supply and demand factors in the broader grain market also heavily influence trends and changes that occur in corn prices.

Throughout time there has always been some skepticism among agricultural audiences in regards to how accurate the USDA quarterly stocks reports are in representing grain supply and demand throughout the growing season. Whether individuals agree with the reports or not, these USDA reports provide market participants an objective standard of comparison for market analysis – being the primary source of public grain market information. Access to this information allows producers, grain merchandisers, end users, and outside speculators to form an educated opinion of the overall sentiment and direction of grain markets. Grain stocks information along with weather forecast predictions, and world-wide USDA supply and demand estimates have tremendous impact on our grain markets.

The University of Illinois published an article “*The Relationship between Stocks-to-Use and Corn Prices Revisited*” (Good and Irwin, 2015). The focus of the study was to analyze two different time periods. The first time period was 1990 to 2006 and the second time period was 2007 to 2015. Over time, the equilibrium price for corn has shifted due to the change in the variables described above. The two time periods studied in the analysis were selected as pre-ethanol boom and throughout the ethanol boom, with the study

analyzing the impact that ethanol production had on corn price. The growth phase of ethanol production resulted in a decline in ending corn stocks throughout the United States. This resulted in a steeper price determination curve in the 2007 to 2015 study. The equilibrium corn price demonstrated the elasticity of demand (i.e., flexibility of demand) as corn stocks to use declined over the time period of 2007 through 2015.

CHAPTER III: METHODS AND DATA

3.1 Methodology

The methods used in this research are centered around statistical and econometric theories involving linear econometric forecasting models. These linear multiple regression-based econometric forecasting models rely on the concept of “myopic forecasting”. Myopic forecasts are based on using data that is known at a point in time (i.e., “today”) to predict in the short term the impacts that independent explanatory variables in an econometric model are going to have on the dependent variables going into the future – based on the most recent relationship observed between these variables over time.

The first step of this study was determining the geographic scope. The geographic scope as stated above represents Western Kansas, with specific grain market locations of Garden City Coop in Garden City, Kansas, and Cornerstone Ag, LLC in Colby, Kansas. Next, the frequency of observations was chosen as weekly data for twenty-two years of weekly basis levels. The weekly basis data represent the basis values associated with weekly Wednesday cash market closes. The data set resulted in 1,056 weekly corn market basis observations each for Garden City Coop and Cornerstone Ag, LLC, over the 2000/21 – 2021/22 marketing year period. The number of data observations (i.e., a total of 1,056 per location) allowed for adequate degrees of freedom for the model estimation. The selection over the 22-year period assumed 48 weekly prices used for each marketing year. The selection of 48 weeks of corn basis data per marketing year follows the approach used on the Kansas State University www.AgManager.info basis data source from which some of this data was obtained. The 48 weeks were standardized by accounting for four weekly pricing periods per month. In instances where five weekly pricing periods per month occurred, weeks four and five were averaged together to represent week four.

This data was compiled through three different sources. The initial source was Kansas State University's www.AgManager.info interactive crop basis tool as stated above. This data set had several gaps for Garden City Coop and Cornerstone Ag, LLC. These data gaps were filled via follow up contact and consultation with both organizations. Garden City Coop provides online historical cash grain prices, and Cornerstone Ag, LLC provided hard copies of grain basis bids for the time periods missing in the data set. Along with the historical cash grain prices grain futures were used to calculate the historical corn basis for the existing data skips.

Another important basis model explanatory variable used in this research was current corn futures. Futures price for corn is observed as the market signal for global demand, while grain basis levels are the market signal for local demand in these selected western Kansas locations. This variable allows for a comparison of the impact of macro grain futures upon micro or local grain basis levels in these western Kansas corn markets. The historical futures prices used in the study were provided by www.macrotrends.com with a 59-year historical daily futures price for corn.

The next set of explanatory data gathered was USDA quarterly grain stocks information. This thesis hypothesized that the scarcity of grain supplies relative to usage in Kansas, as well as the broader United States is one of the key factors determining western Kansas corn basis levels. Quarterly corn stocks information for Kansas and the U.S. are available from the USDA National Agricultural Statistics Service (NASS). NASS estimates of on farm, commercially held, and total quarterly grain stocks for individual states and the United States in aggregate represent quantities available on December 1st, March 1st, June

1st and September 1st. These grain stocks reports provide information on the scarcity of corn supply and demand balances on a quarterly frequency throughout the marketing year.

The USDA September 1st quarterly stocks figure is considered the beginning of the marketing year (which formally ends the previous day, on August 31st). The difference between the previous December 1st quarterly stocks number and following September 1st quarterly stocks demonstrates annual total corn use for the marketing year, covering the September 1st to following August 31st time period. The December 1st quarterly stocks number is observed as the first stocks report for the new marketing year, and provides an estimate of total corn supply. The difference between initial new crop December 1st quarterly stocks and the previous September 1st quarterly stocks is observed as the total harvest production plus changes in the amounts of beginning stocks and imports from the previous marketing year. This twelve month, September 1st through August 31st marketing year format was used in this thesis research analysis.

3.2 Data Observations

One of the first things observed once the basis data were compiled was the seasonality of grain basis for both locations. This was broken into percentile ranges to display the average trading ranges along with highlighting historical abnormal corn basis levels. Figures 3.1 and 3.2 both display the strength, seasonality, and trading ranges of corn basis for both locations. The maximum basis levels observed for Garden City Co-op over the 2000/01 – 2021/22 marketing year period was a positive \$1.64 per bushel, compared to a positive basis level of \$1.76 per bushel for Cornerstone Ag during the same time frame. The minimum basis trading levels were -\$0.55 per bushel for Garden City Co-Op, and -\$1.02 per bushel for Cornerstone Ag. Figures 3.1 and 3.2 illustrates average basis trends and seasonality for the Garden City Co-op and Cornerstone Ag Colby markets. Generally

strongest basis levels seasonally occur summer months i.e., weeks 24-34 in both markets. Average basis is marginally weaker during the first three months of the calendar year in comparison to the last three months in both locations.

Figure 3.1: Garden City Coop Corn Basis Seasonality Weekly 2000/01 – 2021/22

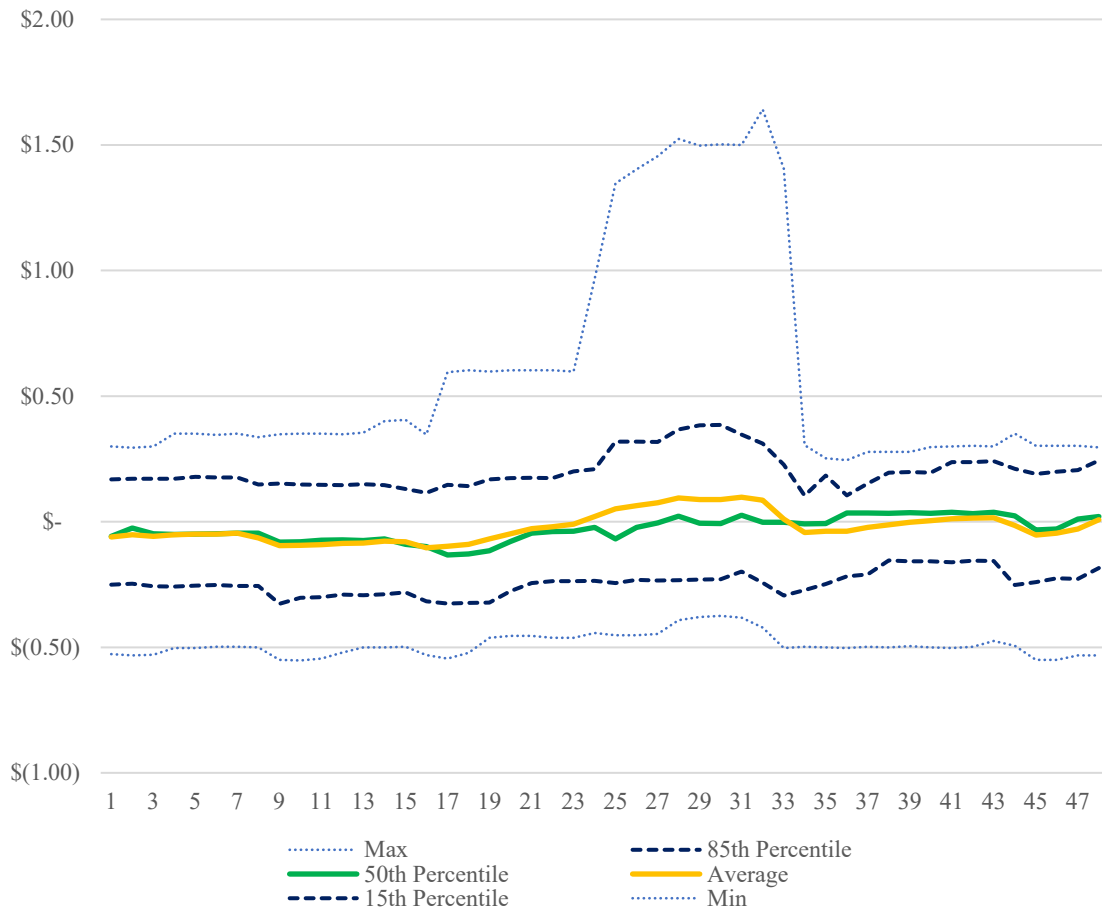
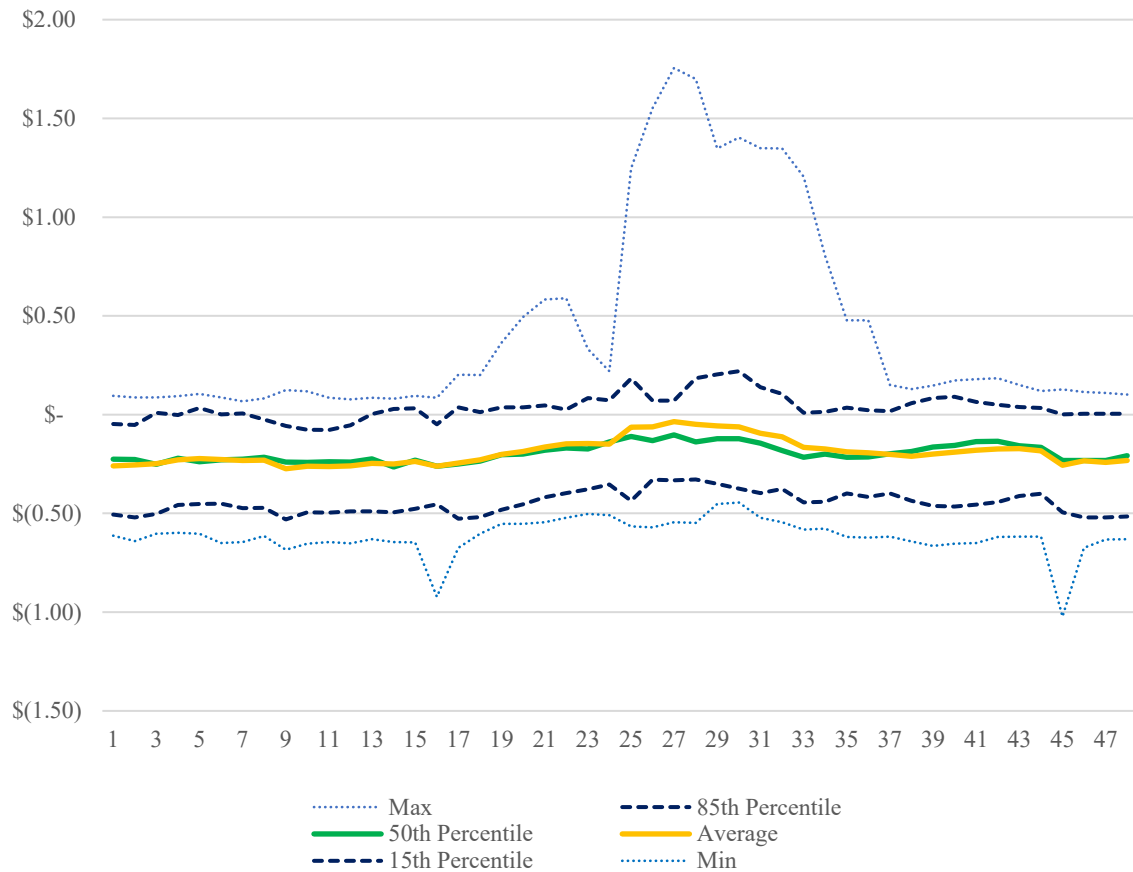


Figure 3.2: Cornerstone Ag ^(Colby) Corn Basis Seasonality Weekly 2000/01 – 2021/22



3.3 Model

As stated above, the relative scarcity of corn stocks in Kansas and the broader United States or lack thereof is hypothesized to be a key factor affecting Western Kansas corn basis over time within the marketing years considered in the study. Changes that occur in corn supply and demand factors as monthly estimates of crop production, feed usage, corn usage for ethanol production, and corn imports and exports, are likely to be useful if the data is available. To a large degree in this thesis, this data is represented in the USDA quarterly grain stocks and stocks-to-use numbers. For this analysis, the use of USDA quarterly stocks report data allows these calculations to have more validity versus difficult implicit calculations which would be required for certain variables discussed above.

The weekly frequency of difference between Western Kansas cash market corn prices and basis to be analyzed differ from the quarterly data available for Kansas and U.S. grain stocks. This difference forces the use of the most recent USDA quarterly stocks, and supply and demand balance data over the three-month quarterly period as an explanatory independent variable that may help determine weekly corn basis levels for the relevant quarterly time period.

Throughout the time period of the 2000/01 to 2021/22 marketing years observed in this study, the expansion of U.S. ethanol was hypothesized to have greatly impacted the levels of domestic corn usage and therefore local corn basis as stated above. The time period of ethanol expansion was initiated by the U.S. Renewable Fuel Standards (RFS) as part of the U.S. Clean Air Act (with a 1978 waiver to the initial Clean Air Act) which mandated the reduction of greenhouse gases. The RFS program was modified by the Environmental Protection Agency and the Congressional Research Service “to ensure that transportation fuel sold in the United States contains a minimum volume of renewable fuel” as part of the Energy Independence and Security Act of 2007 (Yacobucci 2008). The goal of this modification was to expand the required use of 9.0 billion gallons of renewable fuels in 2008 to an increased number of 36.0 billion gallons of renewable fuels by 2022 (Yacobucci 2008) (United States Environmental Protection Agency 2024). The expansion time period for this model was determined as 2006 through 2011. Post 2011, U.S. ethanol production remained at high levels, but with markedly less annual growth than the expansion period of 2006 to 2011. These two time periods were initially represented in this analysis as independent explanatory variables. Initial analyses showed that the ethanol expansion period during 2006-2011 had an insignificant statistical effect on local grain

basis. Therefore, it was removed as an explanatory variable from the study. A dummy variable will be used to analyze the impact the time period 2012-2022 had on corn basis.

The initial regression models ran in the analysis for this thesis work are seen below.

Model #1 Cornerstone Ag Corn Basis Lagged

$$Y(\text{CORNERSTONEAGBASIS}_t) = b_0 + (b_1 * \text{CORNERSTONEAGBASIS}_{t-1}) + (b_2 * \text{FUTURES}_t) + (b_3 * \text{DVSEP}_t) + (b_4 * \text{DVNOV}_t) + (b_5 * \text{DVDEC}_t) + (b_6 * \text{DVJAN}_t) + (b_7 * \text{DVFEB}_t) + (b_8 * \text{DVMAR}_t) + (b_9 * \text{DVAPR}_t) + (b_{10} * \text{DVMAY}_t) + (b_{11} * \text{DVJUN}_t) + (b_{12} * \text{DVJUL}_t) + (b_{13} * \text{DVAUG}_t) + (b_{14} * \text{DV2012-2022}_t) + (b_{15} * \text{KS STOCKS}_t) + (b_{16} * \text{U.S. STOCKS}_t) + e_t$$

Model #1: Cornerstone Ag corn basis is the dependent variable. Beta one (b_1) is the beta coefficient representing the impact Cornerstone Ag's basis the prior week had on the dependent variable. The initial assumption of this model is that the basis level at Cornerstone Ag from the prior week will have a coefficient close to 1. The hypothesis is that this coefficient will have a positive sign of basis unit changes in the same direction. This explanatory variable is also hypothesized to have a statistically significant p-value.

The beta two (b_2) represents the impact made by current futures prices upon the current week's basis value at Cornerstone Ag. The testable hypothesis for this explanatory variable is that futures will have a beta coefficient less than one, with a hypothesized negative sign. This hypothesis is based on an assumed negative relationship between futures and basis, as local demand is using basis as a pricing mechanism to signal demand needs to local producers.

Beta three (b_3) through beta thirteen (b_{13}) represent the seasonality impact each month provides to Cornerstone Ag basis levels. This includes every month in a marketing year format as discussed above - except for the month of October. The month of October

has been selected as the harvest month and is observed in the error term for this model. This is to avoid possible model multicollinearity issues. Multicollinearity is an econometric property that occurs when changes in one explanatory independent variable is directly linked or “correlated” with another such model explanatory independent variable. This would likely lead to inaccurate beta coefficients as measures of explanatory variable impacts on the model independent variables. In this particular model, the seasonal monthly beta coefficients are ordered in the same marketing year format as the corn marketing year, and not in a traditional calendar year (January through December) format. U.S. corn marketing years begin in September and end the following year at the completion of the following August.

The initial hypothesis for these beta coefficients is that the seasonality of basis will show up in coefficient values along with signs. In western Kansas, the month of September is expected to have a larger impact on local corn basis because of the competition for wet corn in the area beginning early in the month. The assumption is that this model variable will have a positive sign. The months of November and December are hypothesized to have a positive model beta coefficient along with a coefficient like September. November and December are post-harvest months where final harvest information begins to be speculated upon and finalized by the USDA. The months of January, February, and March are expected to be less impactful on the corn basis dependent variable from a seasonality standpoint with the market information unknowns of the upcoming planting intentions, and weather conditions coming into Spring. The p-value of these months may be hypothesized to not be statistically significant with lower expected volatility in the basis market. The months of April through June are hypothesized to have a higher beta coefficient (i.e.,

statistical impact) than the “slower” market winter “lull” months. Beginning in April, the corn market typically begins to gain confidence with anticipated planting intentions.

During the month of April, the market also has a stronger idea of soil moisture levels, along with a typically more accurate forecasted perception of weather conditions that may occur throughout the upcoming growing season. The months of May and June are hypothesized to have a more significant impact on the dependent variable as planting season begins. The overall hypothesis for this time period is that near finalized planted acre numbers along with weather scares will provide volatility in the market which will result in statistically significant model impacts. This volatility is expected to be seen in the futures market as well as in local basis. The last two months of the marketing year of July and August are hypothesized to be impactful as well. Throughout the month of July there is more certainty around corn stocks supply from the previous crop. At this point in the marketing year, local basis markets may see more volatility in corn basis bids as the field condition of the new corn crop, along with old crop stock numbers, may influence local demand for corn.

Beta fourteen (*b14*) demonstrates the effect that ethanol production has had on Cornerstone Ag’s corn basis levels. The testable hypothesis for explanatory variable fourteen is that it will have a positive statistically significant impact on corn basis. Ethanol production had provided a strong alternative demand outlet for Northwest Kansas corn producers.

Beta fifteen (*b15*) represents the model factor displaying the impact that Kansas stocks have on Cornerstone Ag’s corn basis. This model variable is a representation of the current Kansas corn stocks number in parallel with the current basis time period as

compared to the mean average of the entire sample period. The initial hypothesis for the Kansas mean (average) stock representation coefficient is hypothesized to have a negative sign along with a larger explanatory variable coefficient than explanatory variable sixteen (*b16*) which represents total U.S. corn stock levels. State of Kansas grain stocks are hypothesized to have greater statistical significance and a larger magnitude of impact on local grain basis than national grain stock levels. This hypothesis is based on an anticipated larger impact generated from local production issues that occur during years of surplus short supplies in the state of Kansas. The beta sixteen (*b16*) coefficient shows the impact that the broader measure of national U.S. corn stock levels has on the local Cornerstone Ag's corn basis. This coefficient reflects the current USDA U.S. stocks number in parallel with the current basis time period relative to the mean average of the entire sample period. The hypothesis for the USDA U.S. corn stock average representation is expected to have less of a statistically significant impact than the State of Kansas corn stocks number as corn basis is a localized supply and demand pricing mechanism.

Table 3.1 below provides an example of the data used in estimation of the Cornerstone Ag model #1 for years 2000/01 – 2021/22. The table below represents one week of data for each marketing year to illustrate the framework of the model.

Table 3.1 Cornerstone Ag Lagged Basis Model #1

Year	Week	Fut.	CA Basis	CA t-1 Basis	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	12-22	KS Stocks Bu.	KS Mean Rep.	USDA Stocks Bu.	USDA Mean Rep.
2000	33	1.94	-0.37	-0.19	1	0	0	0	0	0	0	0	0	0	0	0	0	53,012,000	0.2592	1,717,549,000	0.3008
2001	37	2.11	-0.18	-0.21	0	0	0	0	0	0	0	0	0	0	0	0	0	48,703,000	0.2381	1,899,108,000	0.3326
2002	41	2.43	0.18	0.17	0	0	1	0	0	0	0	0	0	0	0	0	0	52,284,000	0.2556	1,596,426,000	0.2796
2003	45	2.52	-0.06	0.01	0	0	0	1	0	0	0	0	0	0	0	0	0	202,349,000	0.9894	7,953,775,000	1.3931
2004	1	2.50	-0.06	-0.06	0	0	0	0	1	0	0	0	0	0	0	0	0	202,349,000	0.9894	7,953,775,000	1.3931
2005	5	1.95	-0.10	-0.10	0	0	0	0	0	1	0	0	0	0	0	0	0	304,952,000	1.4910	9,452,488,000	1.6556
2006	9	2.35	-0.25	-0.25	0	0	0	0	0	0	1	0	0	0	0	0	0	239,415,000	1.1706	6,987,328,000	1.2238
2007	13	3.59	0.01	-0.13	0	0	0	0	0	0	0	1	0	0	0	0	0	189,040,000	0.9243	6,068,250,000	1.0629
2008	17	6.13	-0.44	-0.41	0	0	0	0	0	0	0	0	1	0	0	0	0	251,005,000	1.2273	6,858,722,000	1.2013
2009	21	4.33	-0.32	-0.32	0	0	0	0	0	0	0	0	0	0	1	0	0	165,905,000	0.8112	4,261,427,000	0.7464
2010	25	3.78	-0.56	-0.47	0	0	0	0	0	0	0	0	0	0	1	0	0	174,996,000	0.8556	4,310,071,000	0.7549
2011	29	7.06	0.23	0.21	0	0	0	0	0	0	0	0	0	0	0	1	0	143,201,000	0.7002	3,670,332,000	0.6429
2012	33	7.91	-0.07	-0.07	1	0	0	0	0	0	0	0	0	0	0	0	1	47,519,000	0.2323	989,027,000	0.1732
2013	37	4.39	0.15	0.48	0	1	0	0	0	0	0	0	0	0	0	0	1	26,719,000	0.1306	821,185,000	0.1438
2014	41	3.70	-0.10	-0.11	0	0	1	0	0	0	0	0	0	0	0	0	1	39,173,000	0.1915	1,231,904,000	0.2158
2015	45	3.70	-0.26	-0.20	0	0	0	1	0	0	0	0	0	0	0	0	1	409,981,000	2.0045	11,235,178,000	1.9678
2016	1	3.53	-0.30	-0.30	0	0	0	0	1	0	0	0	0	0	0	0	1	409,981,000	2.0045	11,235,178,000	1.9678
2017	5	3.68	-0.60	-0.60	0	0	0	0	0	1	0	0	0	0	0	0	1	463,545,000	2.2664	12,383,471,000	2.1690
2018	9	3.87	-0.53	-0.48	0	0	0	0	0	0	1	0	0	0	0	0	1	327,159,000	1.5996	8,892,126,000	1.5575
2019	13	3.63	-0.37	-0.40	0	0	0	0	0	0	0	1	0	0	0	0	1	333,249,000	1.6294	8,613,206,000	1.5086
2020	17	3.14	-0.35	-0.29	0	0	0	0	0	0	0	0	1	0	0	0	1	358,735,000	1.7540	7,951,576,000	1.3927
2021	21	6.75	0.25	0.41	0	0	0	0	0	0	0	0	0	1	0	0	1	201,387,000	0.9847	4,111,181,000	0.7201
2022	25	7.36	1.54	0.60	0	0	0	0	0	0	0	0	0	0	1	0	1	182,025,000	0.8900	4,346,025,000	0.7612

Model #2 Garden City Co-op Corn Basis Lagged

$$Y (\text{GARDENCITYCOOPBASIS}_t) = b_0 + (b_1 * \text{GARDENCITYCOOPBASIS}_{t-1}) + \\ (b_2 * \text{FUTURES}_t) + (b_3 * \text{DVSEP}_t) + (b_4 * \text{DVNOV}_t) + (b_5 * \text{DVDEC}_t) + (b_6 * \text{DVJAN}_t) + \\ (b_7 * \text{DVFEB}_t) + (b_8 * \text{DVMAR}_t) + (b_9 * \text{DVAPR}_t) + (b_{10} * \text{DVMAY}_t) + (b_{11} * \text{DVJUN}_t) + \\ (b_{12} * \text{DVJUL}_t) + (b_{13} * \text{DVAUG}_t) + (b_{14} * \text{DV2012-2022}_t) + (b_{15} * \text{KS STOCKS}_t) + \\ (b_{16} * \text{U.S. STOCKS}_t) + e_t$$

Model #2 has the Garden City corn basis as the dependent variable. Beta one (b_1) is the beta coefficient representing the impact Garden City Coop's basis the prior week had on the dependent variable. The testable hypothesis for this explanatory variable is that it has a positive statistically significant sign with a value near 1.

The model coefficient beta two (b_2) represents the impact made by current futures prices upon the basis level at Garden City Coop. The testable hypothesis is similar to what was stated above for model #1. It is expected there will be a negative relationship between future prices and the unit change in corn basis. The reasoning behind this testable hypothesis is that it has been observed during times of strong, upward price moves in the corn market that as corn futures prices have risen, local corn basis levels have at times weakened in the western Kansas region. The converse has also happened at times during weakening corn markets.

Beta three (b_3) through beta thirteen (b_{13}) represent the seasonal impact that each month has upon the Garden City Coop's basis levels. This includes every month in a marketing year format as discussed above except for the month of October. The month of October has been selected as the harvest month, and is observed as part of the Y-intercept or constant term for this model. The inclusion of these monthly seasonal explanatory variables is to help the model avoid multicollinearity issues. Multicollinearity is when one

independent variable is directly linked to or affected by another individual or group of independent variables. Multicollinearity exists when two or more model explanatory variables are at least somewhat correlated with one another. Multicollinearity would tend to lead to inaccurate beta coefficients resulting from the estimation process. This model is set up in a marketing year format with September 1st as the beginning of the marketing year and August 31st of the following year ending the marketing year.

The seasonality impacts for beta three (b_3) through beta thirteen (b_{13}) are hypothesized in a similar manner as model #1. A few assumptions that differ from model #1 are that the coefficient for the effect of the month of September in model #2 will be larger than the coefficient in model #1 for the Colby grain market. This is assumed to there being more local demand points for early wet corn in the Garden City region with such a proximity to the predominant cattle feeding industry in Garden City compared to Cornerstone Ag in Colby, Kansas. Another assumption is that the summer period of the corn growing season in July and August will have a similar effect as September does in relationship to those time periods. Restated, the impact of such a large quantity of cattle being on feed within the close proximity of Garden City in Southwest Kansas is hypothesized to have a larger impact on corn basis as compared to smaller concentrations of cattle-on-feed in the vicinity of Cornerstone Ag in Colby in the Northwest Kansas corn market. As local stocks diminish into the summer months the Garden City Co-op corn market is assumed to have the first or quicker response to the demand that will arise at that time in relation to Cornerstone Ag – Colby market. The initial hypotheses for the remaining time periods are assumed to be similar to those above in model #1 for the Cornerstone Ag-Colby corn market.

Beta fourteen (*b14*) demonstrates the effect ethanol production has had on Garden City Co-op's corn basis levels. The initial hypothesis for the post-ethanol production time period is that there will be less of an impact in the Garden City corn market compared to Model #1 for the Colby corn market. Although there is ethanol production at the Garden City location, the hypothesis states that the overall demand for corn received from the cattle-feeding industry in the area will outweigh the ethanol demand in the area. The sign of this explanatory coefficient is expected to be positive, but with a less statistically significant coefficient as compared to the previous Colby corn market model above.

Beta fifteen (*b15*) represents the impact that Kansas corn stocks have on Garden City Co-op's corn basis. This explanatory variable represents the impact of current Kansas corn stocks' levels on local corn basis. The initial hypothesis for this explanatory variable is that levels of Kansas corn stocks have a significant negative relationship with Garden City corn basis levels, i.e., that as Kansas corn stocks increase in quantity, the corn basis in Garden City will weaken or become wider.

The beta sixteen (*b16*) coefficient shows the impact United States corn stocks have on Garden City Co-op's corn basis. This coefficient reflects how current U.S. corn stocks relative to the average of U.S. corn stocks for the entire sample period impact Garden City Co-op corn basis levels. The U.S. corn stocks relative to historic mean representation is expected to have a greater impact in the Garden City corn market than Colby market due to the strength of local direct local feed demand in combination with the train unloading capabilities that are in the area. These logistical grain transportation abilities in the Garden City corn market will allow for large quantities of replacement grain to enter the area and

increase local supply at a much greater rate as compared to the location of Model #1 for the Colby corn market.

Table 3.2 below provides an example of the data used in estimation of the Garden City Co-op model #2 for years 2000/01 – 2021/22. The table below represents one week of data for each marketing year to illustrate the framework of the model.

Table 3.2 Garden City Co-op Lagged Basis Model #2

Year	Week	Fut.	GC Basis	GC t-1 Basis	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	12-22	KS Stocks Bu.	KS Mean Rep.	USDA Stocks Bu.	USDA Mean Rep.
2000	33	1.94	-0.25	-0.13	1	0	0	0	0	0	0	0	0	0	0	0	0	53,012,000	0.2592	1,717,549,000	0.3008
2001	37	2.11	0.04	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	48,703,000	0.2381	1,899,108,000	0.3326
2002	41	2.43	0.17	0.15	0	0	1	0	0	0	0	0	0	0	0	0	0	52,284,000	0.2556	1,596,426,000	0.2796
2003	45	2.52	0.07	0.07	0	0	0	1	0	0	0	0	0	0	0	0	0	202,349,000	0.9894	7,953,775,000	1.3931
2004	1	2.50	0.08	0.12	0	0	0	0	1	0	0	0	0	0	0	0	0	202,349,000	0.9894	7,953,775,000	1.3931
2005	5	1.95	-0.04	-0.04	0	0	0	0	0	1	0	0	0	0	0	0	0	304,952,000	1.4910	9,452,488,000	1.6556
2006	9	2.35	-0.19	-0.07	0	0	0	0	0	0	1	0	0	0	0	0	0	239,415,000	1.1706	6,987,328,000	1.2238
2007	13	3.59	-0.03	-0.02	0	0	0	0	0	0	0	1	0	0	0	0	0	189,040,000	0.9243	6,068,250,000	1.0629
2008	17	6.13	-0.23	-0.19	0	0	0	0	0	0	0	0	1	0	0	0	0	251,005,000	1.2273	6,858,722,000	1.2013
2009	21	4.33	-0.22	-0.22	0	0	0	0	0	0	0	0	0	1	0	0	0	165,905,000	0.8112	4,261,427,000	0.7464
2010	25	3.78	-0.45	-0.44	0	0	0	0	0	0	0	0	0	0	1	0	0	174,996,000	0.8556	4,310,071,000	0.7549
2011	29	7.06	0.42	0.39	0	0	0	0	0	0	0	0	0	0	0	1	0	143,201,000	0.7002	3,670,332,000	0.6429
2012	33	7.91	0.05	0.29	1	0	0	0	0	0	0	0	0	0	0	0	1	47,519,000	0.2323	989,027,000	0.1732
2013	37	4.39	0.15	0.15	0	1	0	0	0	0	0	0	0	0	0	0	1	26,719,000	0.1306	821,185,000	0.1438
2014	41	3.70	0.15	0.15	0	0	1	0	0	0	0	0	0	0	0	0	1	39,173,000	0.1915	1,231,904,000	0.2158
2015	45	3.70	0.00	0.00	0	0	0	1	0	0	0	0	0	0	0	0	1	409,981,000	2.0045	11,235,178,000	1.9678
2016	1	3.53	0.00	0.00	0	0	0	0	1	0	0	0	0	0	0	0	1	409,981,000	2.0045	11,235,178,000	1.9678
2017	5	3.68	-0.50	-0.50	0	0	0	0	0	1	0	0	0	0	0	0	1	463,545,000	2.2664	12,383,471,000	2.1690
2018	9	3.87	-0.25	-0.22	0	0	0	0	0	0	1	0	0	0	0	0	1	327,159,000	1.5996	8,892,126,000	1.5575
2019	13	3.63	-0.15	-0.15	0	0	0	0	0	0	0	1	0	0	0	0	1	333,249,000	1.6294	8,613,206,000	1.5086
2020	17	3.14	-0.10	-0.08	0	0	0	0	0	0	0	0	1	0	0	0	1	358,735,000	1.7540	7,951,576,000	1.3927
2021	21	6.75	0.60	0.60	0	0	0	0	0	0	0	0	0	1	0	0	1	201,387,000	0.9847	4,111,181,000	0.7201
2022	25	7.36	0.44	1.10	0	0	0	0	0	0	0	0	0	0	1	0	1	182,025,000	0.8900	4,346,025,000	0.7612

Model #3 Colby Cornerstone Ag Corn Market, Lagged Basis Included

$$Y(\text{CORNERSTONEAGBASIS}_t) = b_0 + (b_1 * \text{CORNERSTONEAGBASIS}_{t-1}) + (b_2 * \text{GARDENCITYCOOPBASIS}_{t-1}) + (b_3 * \text{FUTURES}_t) + (b_4 * \text{DVSEP}_t) + (b_5 * \text{DVNOV}_t) + (b_6 * \text{DVDEC}_t) + (b_7 * \text{DVJAN}_t) + (b_8 * \text{DVFEB}_t) + (b_9 * \text{DVMAR}_t) + (b_{10} * \text{DVAPR}_t) + (b_{11} * \text{DVMAY}_t) + (b_{12} * \text{DVJUN}_t) + (b_{13} * \text{DVJUL}_t) + (b_{14} * \text{DVAUG}_t) + (b_{15} * \text{DV2012-2022}_t) + (b_{16} * \text{KS STOCKS}_t) + (b_{17} * \text{U.S. STOCKS}_t) + e_t$$

Model #3 for Cornerstone Ag, Colby Corn Basis is the same as Model #1 except for adding one lagged cross market explanatory variable. Model #3 includes all the explanatory variables as Model #1 plus Garden City Coop's lagged corn basis for the prior week. This model demonstrates the impact Garden City Co-op's lagged corn basis has on Cornerstone Ag in Colby corn basis. The initial beta assumptions for Model #3 are the same as Model #1 with no major anticipated changes in coefficients and statistical significance. The hypothesis for the impact of Garden City's previous weekly basis is assumed to have statistical significance along with a coefficient close to the value of 1. The initial hypothesis is that with Garden City being centrally located in Southwest Kansas, the corn demand center will have a strong correlation with current corn basis at Cornerstone Ag in Colby due to the regional pull of demand experienced from that regional location.

$$\begin{aligned}
& \text{Model \#4 Garden City COOP and Cornerstone Ag Lagged Garden City COOP Lagged} \\
& Y(\text{GARDENCITYCOOPBASIS}_t) = b_0 + (b_1 * \text{CORNERSTONEAGBASIS}_{t-1}) + \\
& (b_2 * \text{GARDENCITYCOOPBASIS}_{t-1}) + (b_3 * \text{FUTURES}_t) + (b_4 * \text{DVSEP}_t) + (b_5 * \text{DVNOV}_t) \\
& + (b_6 * \text{DVDEC}_t) + (b_7 * \text{DVJAN}_t) + (b_8 * \text{DVFEB}_t) + (b_9 * \text{DVMAR}_t) + (b_{10} * \text{DVAPR}_t) + \\
& (b_{11} * \text{DVMAY}_t) + (b_{12} * \text{DVJUN}_t) + (b_{13} * \text{DVJUL}_t) + (b_{14} * \text{DVAUG}_t) + (b_{15} * \text{DV2012-} \\
& \text{2022}_t) + (b_{16} * \text{KS STOCKS}_t) + (b_{17} * \text{U.S. STOCKS}_t) + e_t
\end{aligned}$$

Model #4 is the same as Model #2 except for adding one lagged cross market explanatory variable. Model #4 for Garden City Co-op's corn basis includes the Cornerstone Ag of Colby corn lagged basis for the prior week. The goal of this model is to observe the impact of lagged Cornerstone Ag of Colby's corn basis from the prior week on Garden City's corn basis. The initial hypothesis for this model is that Cornerstone Ag of Colby's lagged corn basis value from the previous week will have a minimal impact on Garden City's corn basis due to the relative strength of grain demand in Garden City compared to the Cornerstone Ag-Colby location.

Table 3.3 below provides an example of the data used in estimation of the composite Garden City Co-op model #3 and Cornerstone Ag model #4 for years 2000/01 – 2021/22. The table below represents one week of data for each marketing year to illustrate the framework of the model.

Table 3.3 Cornerstone Ag and Garden City Descriptive Data by Year For Models #3 and #4

Year	Week	Fut.	GC Basis	GC t-1 Basis	CA Basis	CA t-1 Basis	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	12-22	KS Stocks Bu.	KS Mean Rep.	USDA Stocks Bu.	USDA Mean Rep.
2000	33	1.94	-0.25	-0.13	-0.37	-0.19	1	0	0	0	0	0	0	0	0	0	0	0	0	53,012,000	0.2592	1,717,549,000	0.3008
2001	37	2.11	0.04	0.03	-0.18	-0.21	0	0	0	0	0	0	0	0	0	0	0	0	0	48,703,000	0.2381	1,899,108,000	0.3326
2002	41	2.43	0.17	0.15	0.18	0.17	0	0	1	0	0	0	0	0	0	0	0	0	0	52,284,000	0.2556	1,596,426,000	0.2796
2003	45	2.52	0.07	0.07	-0.06	0.01	0	0	0	1	0	0	0	0	0	0	0	0	0	202,349,000	0.9894	7,953,775,000	1.3931
2004	1	2.50	0.08	0.12	-0.06	-0.06	0	0	0	0	1	0	0	0	0	0	0	0	0	202,349,000	0.9894	7,953,775,000	1.3931
2005	5	1.95	-0.04	-0.04	-0.10	-0.10	0	0	0	0	0	1	0	0	0	0	0	0	0	304,952,000	1.4910	9,452,488,000	1.6556
2006	9	2.35	-0.19	-0.07	-0.25	-0.25	0	0	0	0	0	0	1	0	0	0	0	0	0	239,415,000	1.1706	6,987,328,000	1.2238
2007	13	3.59	-0.03	-0.02	0.01	-0.13	0	0	0	0	0	0	0	1	0	0	0	0	0	189,040,000	0.9243	6,068,250,000	1.0629
2008	17	6.13	-0.23	-0.19	-0.44	-0.41	0	0	0	0	0	0	0	0	1	0	0	0	0	251,005,000	1.2273	6,858,722,000	1.2013
2009	21	4.33	-0.22	-0.22	-0.32	-0.32	0	0	0	0	0	0	0	0	0	1	0	0	0	165,905,000	0.8112	4,261,427,000	0.7464
2010	25	3.78	-0.45	-0.44	-0.56	-0.47	0	0	0	0	0	0	0	0	0	0	1	0	0	174,996,000	0.8556	4,310,071,000	0.7549
2011	29	7.06	0.42	0.39	0.23	0.21	0	0	0	0	0	0	0	0	0	0	0	1	0	143,201,000	0.7002	3,670,332,000	0.6429
2012	33	7.91	0.05	0.29	-0.07	-0.07	1	0	0	0	0	0	0	0	0	0	0	0	1	47,519,000	0.2323	989,027,000	0.1732
2013	37	4.39	0.15	0.15	0.15	0.48	0	1	0	0	0	0	0	0	0	0	0	0	1	26,719,000	0.1306	821,185,000	0.1438
2014	41	3.70	0.15	0.15	-0.10	-0.11	0	0	1	0	0	0	0	0	0	0	0	0	1	39,173,000	0.1915	1,231,904,000	0.2158
2015	45	3.70	0.00	0.00	-0.26	-0.20	0	0	0	1	0	0	0	0	0	0	0	0	1	409,981,000	2.0045	11,235,178,000	1.9678
2016	1	3.53	0.00	0.00	-0.30	-0.30	0	0	0	0	1	0	0	0	0	0	0	0	1	409,981,000	2.0045	11,235,178,000	1.9678
2017	5	3.68	-0.50	-0.50	-0.60	-0.60	0	0	0	0	0	1	0	0	0	0	0	0	1	463,545,000	2.2664	12,383,471,000	2.1690
2018	9	3.87	-0.25	-0.22	-0.53	-0.48	0	0	0	0	0	0	1	0	0	0	0	0	1	327,159,000	1.5996	8,892,126,000	1.5575
2019	13	3.63	-0.15	-0.15	-0.37	-0.40	0	0	0	0	0	0	0	1	0	0	0	0	1	333,249,000	1.6294	8,613,206,000	1.5086
2020	17	3.14	-0.10	-0.08	-0.35	-0.29	0	0	0	0	0	0	0	0	1	0	0	0	1	358,735,000	1.7540	7,951,576,000	1.3927
2021	21	6.75	0.60	0.60	0.25	0.41	0	0	0	0	0	0	0	0	0	1	0	0	1	201,387,000	0.9847	4,111,181,000	0.7201
2022	25	7.36	0.44	1.10	1.54	0.60	0	0	0	0	0	0	0	0	0	0	1	0	1	182,025,000	0.8900	4,346,025,000	0.7612

CHAPTER IV: MODEL RESULTS

4.1 Cornerstone Ag Model Estimation and Back cast

4.1.1 Cornerstone Ag Model Estimation

Table 4.1 Cornerstone Ag Corn Basis Model #1

OLS, using observations 1-1056, Dependent variable: CornerstoneAg_t

Variable	Coefficient	Standard Error	t-ratio	p-value	Level of Significance
Constant	-0.0062	0.0130	-0.479	0.6321	
CornerstoneAg _{t-1}	0.9458	0.0102	92.610	<0.0001	***
Futures _t	0.0017	0.0020	0.870	0.3846	
DV _{Sep}	-0.0186	0.0126	-1.479	0.1395	
DV _{Nov}	0.0022	0.0126	0.172	0.8633	
DV _{Dec}	0.0780	0.0377	2.066	0.0391	**
DV _{Jan}	0.0982	0.0376	2.607	0.0093	***
DV _{Feb}	0.0906	0.0378	2.395	0.0168	**
DV _{Mar}	0.0431	0.0257	1.674	0.0944	*
DV _{Apr}	0.0573	0.0258	2.222	0.0265	**
DV _{May}	0.0790	0.0259	3.044	0.0024	***
DV _{Jun}	0.0362	0.0168	2.154	0.0314	**
DV _{Jul}	0.0673	0.0171	3.930	<0.0001	***
DV _{Aug}	0.0180	0.0171	1.056	0.2913	
DV ₂₀₁₂₋₂₀₂₂	0.0144	0.0071	2.046	0.0410	**
KS Stocks vs Avg	0.0159	0.0210	0.758	0.4488	
U.S. Stocks vs Avg	-0.0775	0.0393	-1.971	0.0490	**
Mean dependent var	-0.166	S.D. dependent var		0.316	
Sum squared resid	7.263	S.E. of regression		0.084	
R-squared	0.931	Adjusted R-squared		0.930	
F(16, 1039)	874.793	P-value(F)		0.000	
Log-likelihood	1,130.752	Akaike criterion		-2,227.504	
Schwarz criterion	-2,143.145	Hannan-Quinn		-2,195.527	
rho	-0.009	Durbin-Watson		2.007	
***	1% L.O.S				
**	5% L.O.S				
*	10% L.O.S				

Model #1 estimation results are observed above. The constant in this econometric model represents the corn harvest month of October as it was the month left out of the dummy variables representing the monthly marketing year seasonality of basis, plus the

impact of other explanatory variables not included in the model. The next independent variable, beta one (b_1), represents the impact Cornerstone Ag's basis from the previous week (i.e., lagged one period) has a significant positive effect on the model dependent variable representing the current week's basis in Colby. The model shows that for every \$1.00 positive change from the previous week in corn basis at Cornerstone Ag-Colby, there is a +\$0.94582 change in basis that occurred for the current week at Cornerstone Ag. Restating this in terms of cents, every +\$0.01 per bushel change in the previous week's corn basis at Cornerstone Ag in Colby has a +\$0.0094582 or approximately +\$0.0946 per bushel positive affect on the current week's CornerstoneAg-Colby corn basis. The p-value for the lagged weekly basis at Cornerstone Ag demonstrates statistical significance at the 1% level.

The beta two (b_2) coefficient representing the impact of corn futures market price changes on CornerstoneAg-Colby corn basis displays a positive change of 0.00172001/unit changes in basis (or +\$0.00172 per bushel) for every \$1.00 per bushel unit change in futures prices. However, this explanatory variable was not statistically significant.

Dummy variables b_3 through b_{13} represent the impact of monthly seasonality of CornerstoneAg-Colby corn basis beginning with the month of September. The month of September reflects a negative but not statistically significant impact upon corn basis at Cornerstone Ag-Colby. The independent variable beta four (b_4) the month of November has a positive but not statistically significant impact on the CornerstoneAg-Colby corn basis. The month of November was hypothesized to have a positive unit change in corn basis at Cornerstone Ag in Colby compared to the month of September. This follows from the idea that U.S. corn supply numbers are more uncertain and speculative in the beginning

of September with an limited amount of real harvest data available to the western Kansas corn market from early harvest of wet corn for use by feedlots in the area. However, by the month of November, there is more confidence in the actual harvest numbers available to the western Kansas and broader U.S. corn market. Initially, the author would assume that the confidence in these numbers allows for a statistically significant impact from the independent variable in the model. All that said, the volatility existing in these western Kansas and U.S. corn harvest numbers causes neither the September nor November explanatory variables to be statistically significant.

Following the harvest period through the month of November, the seasonal monthly December through July explanatory variables all have some form of statistically significant impacts upon the CornerstoneAg-Colby corn basis. The month of December has a beta coefficient (*b5*) of 0.0779685, resulting in a positive unit change of Cornerstone Ag's corn basis of +\$0.0779685 per bushel which is statistically significant at the 5% level. The month of January results in a positive beta coefficient (*b6*) of +0.0981635/unit change in basis for Cornerstone Ag, which is statistically significant at the 1% level. The beta coefficient (*b7*) for the month of February is also positive with a coefficient of +0.0905791 resulting in a positive change in corn basis and is statistically significant at the 5% level.

Through the months of December (*b5*), January (*b6*), and February (*b7*), the beta coefficients were each positive and statistically significant – representing postharvest basis improvements. The month of March had a significantly smaller significant impact than the previous three months with a beta coefficient (*b8*) resulting in a unit change of 0.0430948 units of corn basis with a statistical significance at the 10% level. The month of April (*b9*) has a similar statistically significant impact to the month of March with a beta coefficient

of 0.0573227, with a statistical significance of 5%. Following the month of April with planting conditions and weather, the month of May (*b10*) has a larger beta coefficient (i.e., impact on CornerstoneAg-Colby corn basis) than the previous two months, at +0.0789918, with a statistical significance level of 1%. The month of June (*b11*) has a smaller beta coefficient compared to the previous month with a value of +0.0361657, with a statistical significance of 5%. The month of July (*b12*) demonstrates a beta coefficient of +0.0672518 with level of statistical significance of 1%. Lastly, the month of August (*b13*) demonstrates a coefficient of +0.0180418, which is statistically significant at the 10% level.

The ethanol production years of 2012 through 2022 (i.e., model explanatory variable “DV2012-2022”) demonstrate a positive basis impact, with a unit change of basis by +0.0144414 units with a statistical significance of 5%. Kansas corn stock levels (i.e., model explanatory variable “KS Stocks vs Avg”) had a +0.0159257 per unit change in CornerstoneAg-Colby corn basis with a statistical significance of 10%. The USDA corn stock coefficient (i.e., model explanatory variable “U.S. Stocks vs Avg”) provided a -0.0775049 unit change in corn basis with a 5% level of statistical significance.

In summary, the strongest impact on corn basis at Cornerstone Ag is observed from the previous week’s basis levels at Cornerstone Ag in Colby - being the largest positive (or negative) coefficient value (in an absolute value sense), being statistically significant at the 1% level. The independent variables with second largest positive, statistically significant impacts on the corn basis levels of Cornerstone Ag are the postharvest months of January, May, and July. The only independent explanatory variable that had a negative impact on Cornerstone Ag’s basis (compared to the October harvest period basis represented by the model constant) that was statistically significance was the U.S. Stocks vs Avg variable.

This model demonstrated a high r-squared value of 0.930898, with an adjusted r-squared value of 0.929834. This shows the ability of the model explain the variability observed by the dependent variable – in this case the CornerstoneAg-Colby weekly corn basis. The Durbin Watson value in this model is 2.006591, displaying low autocorrelation.

4.1.2 Cornerstone Ag Back Cast

Following the model estimation that included Cornerstone Ag's lagged weekly corn basis as an explanatory variable, an adjusted in-sample back-casting approach was used to help verify the practical usefulness of the model for farm market decision making. The linear regression analysis was calculated using the sample observations through three marketing years. The three years that the sample size was back casted for were the 2019-2020 marketing year, 2020-2021 marketing year, and 2021-2022 marketing year. Corn marketing years begin on September 1st and end the following August 31st. Once the regression analysis was computed for the combined 2020-2021 and 2021-2022 marketing years, and the model used to forecast the 2019-2020 weekly basis, and in similar manner for the 2020-2021 and 2021-2022 marketing years, the basis values were forecasted and charted and compared with the actual known basis values for those marketing years. The back cast results for marketing year 2021-2022 will be displayed below.

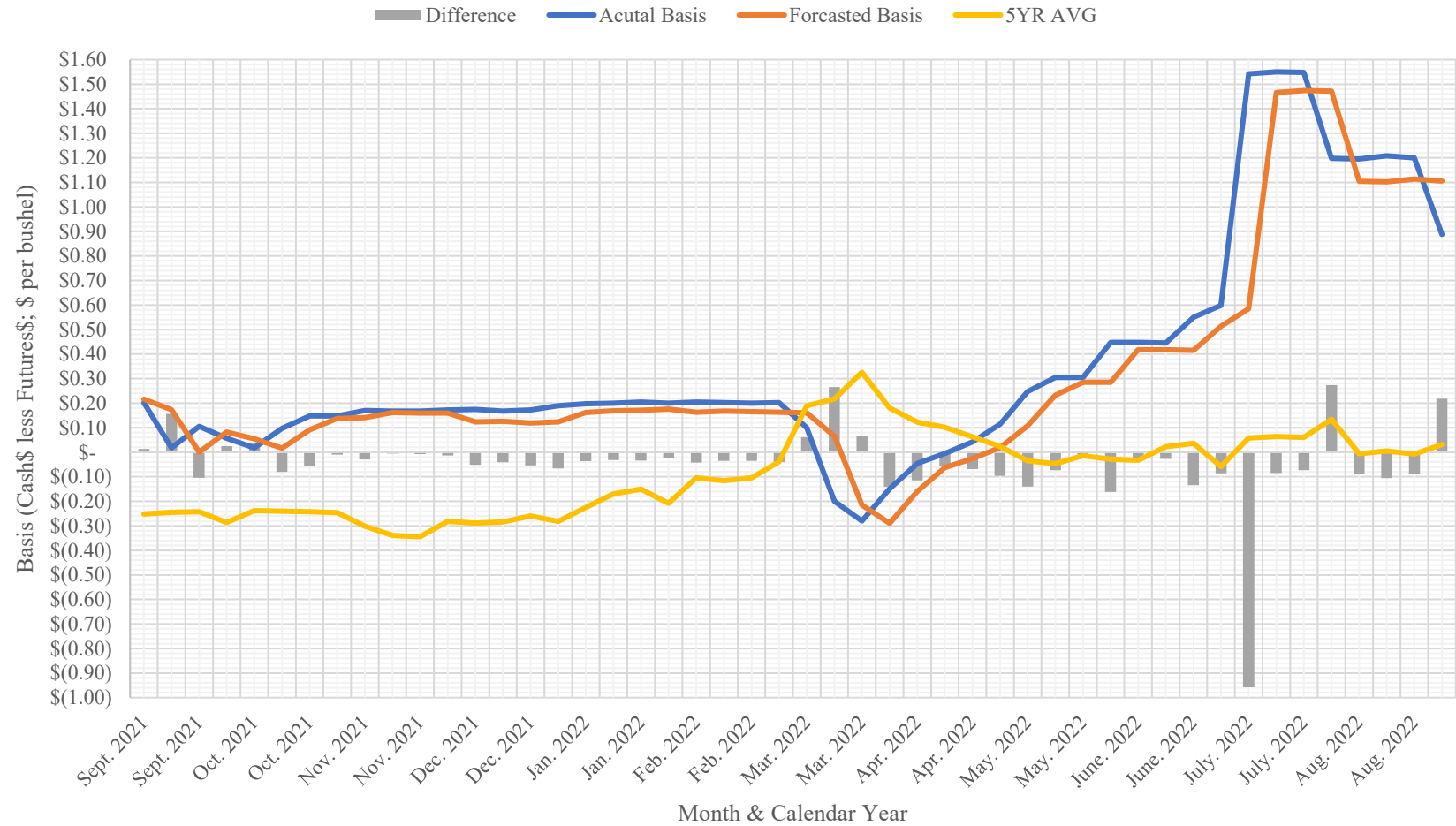
The results from Cornerstone Ag in Colby corn basis back cast model follow closely with the actual results. Table 4.1 displays a few statistics demonstrating the effectiveness of the back cast models. The main observation in Table 4.1 is that as the standard deviation increased so did the root mean square error values. Root mean square error value demonstrates the accuracy of the back cast model, using the average squared difference between the actual value and forecasted value. Once the average squared difference is calculated the square root of that value equals the root mean square.

Table 4.2 Cornerstone Ag Back Cast

Model Year	Standard Deviation	Skewness	Average	RMSE
2019-2020	0.1291	1.1287	-0.0100	0.0327
2020-2021	0.2279	1.1925	-0.0100	0.1718
2021-2022	0.4618	1.5111	-0.0500	0.1681

The results of these back-cast model estimates were compared to the previous 5-year average basis values computed by www.agmanager.info interactive basis tool. The regression model involved in this research seems to forecast a more accurate basis value compared to the 5-year historical average. This is hypothesized to be true due to the short-term supply and demand factors that heavily influence basis values in any current marketing year. The 5-year historical average does a very good job of displaying the historical seasonality of basis, but doesn't have enough real time insight or "current context" to provide guidance of future basis values. This issue is demonstrated below throughout the March and April, 2022 time period. Historically over the last five years, March-April has been a beneficial time seasonally to set basis for post-harvest cash corn sales. However, during March-April 2022 corn basis actually basis declined sharply during that part of the 2021-2022 marketing year (i.e., September 1, 2021 through August 31, 2022).

Figure 4.1: Colby Marketing Year 2021-2022 Forecasted Model



4.2 Garden City Coop Model Estimation and Back cast

4.2.1 Garden City Coop Model Estimation

Table 4.3 Garden City Coop Corn Basis Model#2

OLS, using observations 1-1056, Dependent variable: GardenCityCoop_t

Variable	Coefficient	Standard Error	t-ratio	p-value	Level of Significance
Constant	-0.0068	0.0116	0.588	0.5569	
GardenCityCoop _{t-1}	0.9595	0.0093	103.200	<0.0001	***
Futures _t	0.0021	0.0018	1.210	0.2264	
DV _{Sep}	-0.0401	0.0113	-3.563	0.0004	***
DV _{Nov}	-0.0136	0.0113	-1.207	0.2276	
DV _{Dec}	0.0420	0.0331	1.268	0.2049	
DV _{Jan}	0.0458	0.0331	1.383	0.1669	
DV _{Feb}	0.0418	0.0332	1.261	0.2075	
DV _{Mar}	0.0180	0.0226	0.796	0.4264	
DV _{Apr}	0.0214	0.0227	0.946	0.3446	
DV _{May}	0.0377	0.0227	1.659	0.0974	*
DV _{Jun}	0.0244	0.0148	1.652	0.0988	*
DV _{Jul}	0.0368	0.0149	2.473	0.0136	**
DV _{Aug}	0.0030	0.0151	0.199	0.8422	
DV ₂₀₁₂₋₂₀₂₂	0.0104	0.0064	1.619	0.1057	
KS Stocks vs Avg	0.0126	0.0187	0.672	0.5018	
U.S. Stocks vs Avg	-0.0498	0.0348	-1.433	0.1523	
Mean dependent var	0.007	S.D. dependent var	0.315		
Sum squared resid	5.786	S.E. of regression	0.075		
R-squared	0.945	Adjusted R-squared	0.944		
F(16, 1039)	1,109.387	P-value(F)	0.000		
Log-likelihood	1,250.795	Akaike criterion	-2,467.590		
Schwarz criterion	-2,383.231	Hannan-Quinn	-2,435.613		
rho	-0.149	Durbin-Watson	1.700		
***	1% L.O.S				
**	5% L.O.S				
*	10% L.O.S				

Model #2 for Garden City is very similar to Model #1 for Cornerstone Ag in Colby where the independent variable with the strongest impact is still the lagged basis value from the previous week at each location. This beta coefficient (b_1) demonstrates a value of

+\$0.959503, which is slightly larger than the Cornerstone Ag lagged basis value. Restating this in terms of cents, every +\$0.01 per bushel change in the previous week's corn basis at Garden City Coop has a +\$0.00959503 or approximately +\$0.00960 per bushel positive effect on the current week's Garden City corn basis. The lagged basis p-value in Model #2 is also statistically significant at the 1% level. The futures value beta coefficient (b_2) in the Garden City model demonstrates a slightly larger positive factor effect than the Cornerstone Ag model, although both independent values lack statistical significance at the 10% level.

The month of September (b_3) in the Garden City model has the same negative effect on current corn basis as the month of September in the Cornerstone Ag model, but is statistically significant at the 1% level. This reason for this difference in statistical significance between the models for b_3 is hypothesized to be the greater quantity of cattle on feed within proximity to the Garden City location, and the demand for wet corn being harvested at the first of the month of September. The month of November has a beta coefficient (b_4) of -0.0135848 in the Garden City model, but is not statistically significant – as was the case in the Cornerstone Ag model.

Following the month of November (b_4), December (b_5) through May (b_{10}) displayed positive impacts in basis with small value changes of coefficients ranging from 0.0180086 in March as the highest value in December with a coefficient value of 0.0420438. However, all five of these months failed to be statistically significant at the 10% level. The months of May (b_{10}), June (b_{11}), and July (b_{12}) all had positive impacts on current Garden City basis, ranging from +0.0243791 to +0.0376852, while May and

June were statistically significant at least 10%, while the month of July was statistically significance at the 1% level. The month of August (*b13*) was not statistically significant.

The ethanol production time period (*b14*) of 2012 through 2022 had a positive but not statistically significant impact in the Garden City model compared to the Cornerstone Ag model, where the positive basis effect was statistically significant at the 5% level. That ethanol development in the U.S. would have a significant positive impact on corn basis in Garden City as opposed to the Colby market follows from the idea that there is a larger demand impact in southwest Kansas where larger concentrations of cattle on feed to compete for available supplies along with the ethanol production in this area. The p-value for this independent variable was just outside of the range to have statistical significance at the 10% level. The impact of Kansas corn stock beta coefficient (*b15*) is similar to the Cornerstone Ag value observed. This reflects a positive but statistically insignificant impact on Garden City corn basis of +\$0.0125931 units. The USDA corn stocks number (*b16*) in the Garden City Model has a similar negative impact observed in Cornerstone Ag Model but was not statistically significant.

The R-squared value in this model is strong demonstrating the explanatory variable explanatory ability covered in the model, with a value of 0.944702. This model demonstrated a marginally lower autocorrelation value then the Cornerstone Ag model with a value of 1.700051.

In summary, the Garden City model is very similar to Cornerstone Ag model, with the strongest impact on basis coming from the previous week's own basis value. However, the Garden City model does not reflect as much monthly seasonality as the Cornerstone Ag model does. This model demonstrates that the strongest impacts on basis are observed early

on in the marketing year when wet bushels begin to make their way into the marketplace. The Cornerstone Ag model demonstrates more statistically significant seasonality throughout the winter months with stronger monthly affects then the Garden City model. The Garden City basis model lacks the impact that is observed by the ethanol production era compared to the Cornerstone Ag model. This result shows that the demand that the cattle on feed have a stronger impact on corn basis levels in the west central and southwest portion of the state of Kansas relative to the northwest location of the state.

4.2.2 Garden City Coop Back Cast

After the initial model estimation for the Garden City Coop model, the same back cast model that was computed for Cornerstone Ag's regression model was computed for the Garden City Coop regression model. The back-cast model for the Garden City Coop used the same three marketing years; 2019-2020, 2020-2021, and 2021-2022. The most recent chart for 2021-2022 will be displayed below.

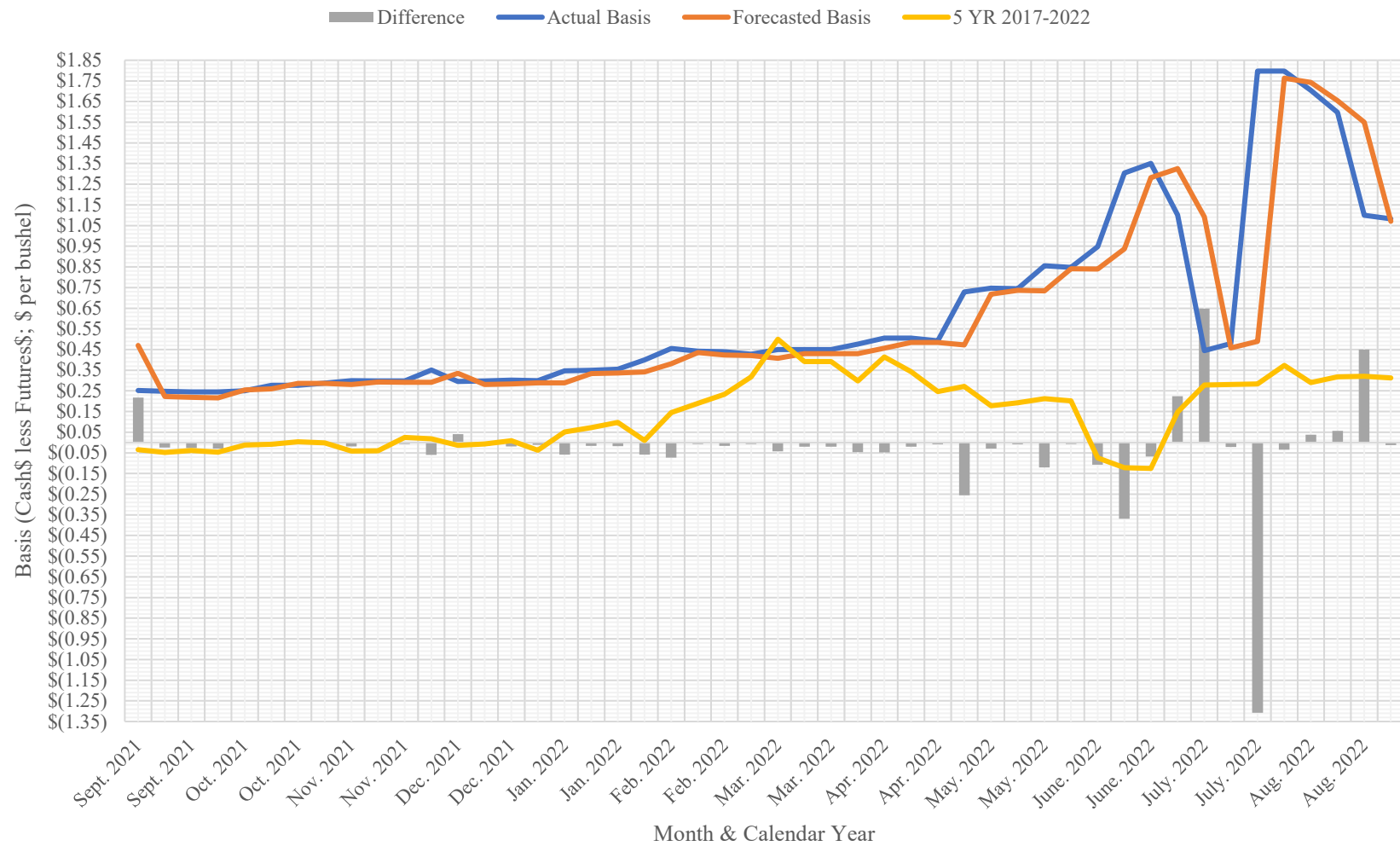
The statistical tools observed in this back cast model are observed below in table 4.4. This table demonstrates similar trends observed in table 4.2. The Garden City Coop back cast models observe low root mean squared error values through the first two marketing years. As the volatility increases in the last marketing year, a greater root mean squared error value is observed. The Garden City model has consistently lower root mean square error values in the first two years even though the volatility observed in basis levels is increasing based on the higher standard deviation values in Table 4.4.

Table 4.4 Garden City Coop Basis Back Cast

Model Year	Standard Deviation	Skewness	Average	RMSE
2019-2020	0.0720	0.8751	-0.0200	0.0251
2020-2021	0.2046	0.6144	-0.0200	0.0758
2021-2022	0.4441	1.4852	-0.0300	0.2371

The Garden City Coop back cast model was also compared to the five-year historical average for its own location from the interactive crop basis tool on www.agmanager.info. The five-year average for Garden City seems to look like a better correlation from a seasonality stand point through the first half of the marketing year. As out of the ordinary supply and demand issues begin to occur in the 2021-2022 marketing year the regression analysis model seems to forecast a more accurate prediction of the actual basis value compared to the historical average

Figure 4.2 Garden City Marketing Year 2021-2022 Forecasted Model



4.3 Composite models

The next two models incorporate the lagged basis values from the opposite location to observe the impact. CornerstoneAg model #3 has the same dependent and independent variables as CornerstoneAg model #1, but with the addition of Garden City's lagged corn basis. Garden City model #4 has the same dependent and independent variables as Garden City model #2 with the addition of Cornerstone Ag's lagged basis.

Table. 4.5 Cornerstone Ag Composite Corn Basis Model #3

OLS, using observations 1-1056, Dependent variable: CornerstoneAg_t

Variable	Coefficient	Standard Error	t-ratio	p-value	Level of Significance
Constant	-0.0167	0.0125	-1.334	0.1824	
CornerstoneAg _{t-1}	0.7665	0.0208	36.890	<0.0001	***
GardenCityCoop _{t-1}	0.2073	0.0212	9.783	<0.0001	***
Futures _t	-0.0031	0.0020	-1.597	0.1106	
DV _{Sep}	-0.0160	0.0121	-1.323	0.1860	***
DV _{Nov}	<0.0000	0.0121	0.008	0.9939	
DV _{Dec}	0.0648	0.0361	1.794	0.0731	*
DV _{Jan}	0.0848	0.0361	2.351	0.0189	**
DV _{Feb}	0.0800	0.0332	2.208	0.0275	**
DV _{Mar}	0.0380	0.0246	1.540	0.1238	
DV _{Apr}	0.0526	0.0247	2.130	0.0334	**
DV _{May}	0.0785	0.0248	3.161	0.0016	*
DV _{Jun}	0.0385	0.0161	2.392	0.0169	*
DV _{Jul}	0.0748	0.0164	4.559	<0.0001	***
DV _{Aug}	0.0126	0.0164	0.767	0.4430	
DV ₂₀₁₂₋₂₀₂₂	0.0015	0.0069	0.217	0.8283	
KS Stocks vs Avg	0.0136	0.0201	0.676	0.4995	
U.S. Stocks vs Avg	-0.0666	0.0377	-1.769	0.0772	*
Mean dependent var	-0.166	S.D. dependent var		0.316	
Sum squared resid	6.650	S.E. of regression		0.080	
R-squared	0.937	Adjusted R-squared		0.936	
F(17, 1038)	904.014	P-value(F)		0.000	
Log-likelihood	1,177.320	Akaike criterion		-2,318.641	
Schwarz criterion	-2,229.320	Hannan-Quinn		-2,284.782	
rho	-0.0529	Durbin-Watson		1.886	
***	1% L.O.S				
**	5% L.O.S				
*	10% L.O.S				

In summary, adding the Garden City lagged basis reduces the positive coefficient value of the own location Cornerstone Ag lagged independent variable, but statistical significance of 1% remains the same. For every unit change, Garden City lagged a basis of 0.207297 unit change is observed at Cornerstone Ag with statistical significance at the 1% level. As far as the other independent variables in the model, the monthly seasonality explanatory variables of the CornerstoneAg corn basis model remain significant but at lower levels of statistical significance compared to CornerstoneAg model #1. The monthly seasonality independent variables that observe a change from the 1% level to the 5% level, or from the 5% level to the 10% level, or ultimately lose statistical significance altogether for the months of December, January, and March. This model structure resulted in lack of statistical significance for the ethanol expansion dummy variable, and to reduced statistical significance for the USDA stock number from 5% to 10%. The R-squared value minimally increases from 0.930898 to 0.936731, while the Durbin Watson test value shifts lower to 1.886040, which is closer to the 1.5 value threshold where autocorrelation becomes a concern.

Table 4.6 Garden City Coop Composite Corn Basis Model #4OLS, using observations 1-1056, Dependent variable: GardenCityCoop_t

Variable	Coefficient	Standard Error	t-ratio	p-value	Level of Significance
Constant	0.0128	0.0114	1.120	0.2630	
CornerstoneAg _{t-1}	0.1277	0.0190	6.729	<0.0001	***
GardenCityCoop _{t-1}	0.8446	0.0193	43.65	<0.0001	***
Futures _t	0.0049	0.0018	2.748	0.0061	***
DV _{Sep}	-0.0427	0.0110	-3.875	0.0001	***
DV _{Nov}	-0.0131	0.0110	-1.185	0.2362	
DV _{Dec}	0.0019	0.0330	0.057	0.9548	
DV _{Jan}	0.0060	0.0329	0.181	0.8564	
DV _{Feb}	-0.0003	0.0332	-0.008	0.9936	
DV _{Mar}	-0.0082	0.0225	-0.363	0.7164	
DV _{Apr}	-0.0052	0.0226	-0.232	0.8169	
DV _{May}	0.0079	0.0227	0.347	0.7288	
DV _{Jun}	0.0072	0.0147	0.488	0.6257	
DV _{Jul}	0.0135	0.0150	0.901	0.3678	
DV _{Aug}	-0.0133	0.0149	-0.890	0.3739	
DV2012-2022	0.0096	0.0063	1.525	0.1277	
KS Stocks vs Avg	0.0072	0.0184	0.392	0.6952	
U.S. Stocks vs Avg	-0.0171	0.0344	-0.497	0.6191	
Mean dependent var	0.007	S.D. dependent var	0.315		
Sum squared resid	5.544	S.E. of regression	0.073		
R-squared	0.947	Adjusted R-squared	0.946		
F(17, 1038)	1,091.295	P-value(F)	0.000		
Log-likelihood	1,273.341	Akaike criterion	-2,510.682		
Schwarz criterion	-2,421.361	Hannan-Quinn	-2,276.824		
rho	0.175	Durbin-Watson	1.649		
***	1% L.O.S				
**	5% L.O.S				
*	10% L.O.S				

The results for Garden City Coop model #4 display the impact of Cornerstone Ag's lagged basis on the current basis value at the Garden City Coop. The added independent variable of Cornerstone Ag's lagged basis causes a change of 0.127657 in Garden City, with

statistical significance at the 1% level. The combined model also causes the statistical significance of the monthly seasonality impacts observed throughout the summer months to decline, falling outside of the 10% level of significance. The only statistically significant independent variables observed in Model #4 are Cornerstone Ag lagged basis values, Garden City Coop lagged basis values, futures values, and the month of September. The R-squared value in the combined model increased slightly, and the Durbin Watson value lowered towards the multicollinearity threshold of 1.5. In conclusion, Garden City Coop seems to be more of a basis leader than Cornerstone. This aligns with the initial hypothesis with the realization of the flow of grain throughout Western Kansas moving grain from Northwest Kansas south towards Southwestern Kansas with large feed demand.

CHAPTER V: CONCLUSION

In summary, the goal of this research was to develop a model that provided a greater understanding of corn basis behavior in Western Kansas, and how certain factors impact the Colby market in northwest Kansas, and Garden City market in southwest Kansas. The key finding of this research is that corn basis in these two key grain markets in Western Kansas depended on somewhat different independent explanatory factors rather than only one or a small set of common, overarching factors across the two markets.

That key explanatory variable in these analyses were the same-market lagged basis levels for both the Colby and Garden City locations. One-week lagged basis at the same market locations had a statistically significance effect at the 1% level with strong beta coefficients for both models. The take away from this is observed in the back-cast models. The five-year historical average was overlayed with the forecasted models with the known basis levels. The estimated basis levels were more accurate based on the regression analysis ran for both locations compared to the five-year historical average. Basis has proven to be so volatile that historical averages did not adequately account for or reflect current grain market supply and demand information to be useful as an accurate guide for an individual's grain marketing strategies and associated marketing actions. Although the five-year historical average basis estimates do represent the general seasonality of corn basis levels for both locations in a normal marketing year, they are only marginally useful as a guide for corn producer's marketing strategy decisions. The previous three years used in this back cast modelling approach include some of the most volatile historic basis level periods observed due to in part to the numerous macro and microeconomic issues that occurred during that time in the United States. These out-of-the ordinary recent U.S. corn marketing

years demonstrated the differences observed between actual weekly basis values as compared to multi-year historical average basis values.

The second major take away from this model revolved around the impact of marketing year seasonality upon Western Kansas corn basis levels that was observed in both models. Corn basis levels from Cornerstone Ag, based out of Colby in northwest Kansas, displayed significantly greater seasonality trends and impacts over more seasonal monthly explanatory variables than for the Garden City Co-op corn basis models in southwest Kansas. The monthly seasonal price factors for the CornerstoneAg-Colby corn basis model displayed greater statistical significance through the winter and early spring months compared to the monthly seasonal impacts in the Garden City Coop corn basis model. The upstream Colby market in a sense provides a grain storage over time function for the downstream Garden City demand center. By definition for corn to be stored and maintain condition it must maintain of no greater than 15% grain moisture content. So that basis signals in the Colby market would incentivize storage of no greater than 15% moisture corn beyond harvest into later months of the marketing year, it therefore would tend to show more basis and price seasonality.

Along with the seasonality of corn basis at these two Western Kansas corn markets, another unique finding involved the opposing impacts of wet corn and ethanol production at the two market locations analyzed in this study. Seasonal demand for wet corn of approximately 28-35% moisture corn in Western Kansas is represented by the September monthly seasonal explanatory variable – prior to regular dry or normal corn harvest at no greater than 15% moisture in October. The wet corn market associated with cattle feeder corn demand demonstrated a larger impact on the Garden City Coop corn basis model than

in the Cornerstone Ag location. A much larger quantity of cattle on feed are located within close proximity to the Garden City Coop location in southwest Kansas than the Cornerstone Ag location at Colby in northwest Kansas. Due to logistical challenges of hauling wet corn over distances it follows that wet corn sales to feedlots have a stronger impact during the September month in the Garden City market than the Colby market.

Corn basis levels at the Cornerstone Ag location in Colby did experience stronger response to the period of ethanol production development than did corn basis at the Garden City location. The predominance of cattle on feed in the Garden City market may tend to lessen the influence of ethanol development in southwest Kansas as opposed to northwest Kansas.

This study could be improved by incorporating the intensity cattle on feed numbers located within a specified distance of the Colby and Garden City market locations. Corn basis levels at alternative nearby regional corn markets could also be considered in these models. Also, freight on board corn basis bids for on farm grain bids would be an additional step that could be considered as well. The local corn basis impact of ethanol in the Colby and Garden City markets could be observed the same way, i.e., based on bid plus transportation cost from local ethanol plant locations in Western Kansas. Freight on board corn basis bids implicitly introduce transportation costs into this model. Throughout the last three years, transportation costs have fluctuated significantly, which may be hypothesized as a potentially having a significant impact on local corn basis in Colby and Garden City in Western Kansas.

Grain transportation costs in western Kansas are estimated to trade within a range of \$0.40 - \$0.60 per bushel for contract grain haulers from Colby in northwest Kansas to

the Garden City southwest Kansas (approximately 106 miles). The average basis difference between Garden City Co-op and Cornerstone Ag, LLC for the harvest month of October is -\$0.17 less at Cornerstone Ag, LLC compared to Garden City Co-op. This indicates most of the time the difference in basis would not offset the hauling charge of shipping grain downstream to Garden City Co-op at harvest time. The basis margin between both locations widens some in the early spring months of March and April to -\$0.19 less at Cornerstone Ag, LLC, but this still doesn't offset the cost of shipping, storage, and handling costs a producer would incur to ship the corn downstream to Garden City Co-op. There are a few exceptions in extremely volatile short supply years where the maximum difference is -\$0.89 at Cornerstone Ag, LLC. This margin is only extremely wide for a week or two and then the efficiency of the market corrects the margin and narrows up quickly. This would result in rare occasions of arbitrage opportunities.

In summary, this study demonstrates what some of the critically important factors are that impact corn basis for both of the Western Kansas market locations discussed above. This analysis also shows the corn market leadership coming from the Garden City area relative to the Colby area in Western Kansas. The difference between the monthly seasonality impacts on corn basis at these two locations provides a better understanding of both the similarities and differences that exist in basis patterns and dynamics between these two prominent Western Kansas corn market centers. Lastly, it has been found that in tight corn market supply years increased futures and cash market volatility can lead to great difficulty in predicting future corn basis values – especially when compared to a less volatile historical average of basis. The best weekly predictor of corn basis observed in this

study is the one week ago basis, or the basis from the prior week, instead of historical averages.

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