Kansas Wheat Basis Expectations During Periods of Nonconvergence

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Abstract

Nonconvergence in commodity markets has caused some market participants to question the effectiveness of using futures contracts to effectively set target prices. This study examines 90 grain handling facilities across Kansas since 2004 and shows spatial patterns of change in hard red winter wheat basis with respect to basis movements at a regular (delivery) facility in Kansas City and the effect of nonconvergence. Producers and farm managers can more accurately predict changes in local basis with this information. Results indicate the presence of nonconvergence at delivery location has a significant effect on basis at some, but not all, outlying locations.

INTRODUCTION

Recent bouts of nonconvergence in agricultural commodities have raised concerns about the effectiveness of futures contracts. Nonconvergence occurs when cash prices diverge from the underlying futures contract more than anticipated during the delivery period. Traders expect the futures price and the cash price at a contract-specified delivery location to trend toward and meet each other as the futures contract matures, because of the threat of arbitrage and delivering against the contract. Nonconvergence results in wider than expected basis and increased risk exposure to market participants.

Futures markets are a central fixture in agricultural commodity marketing. Adjemian et al. (2013) discuss price discovery, risk management opportunities, and a source for storage signals as core functions of futures markets. Arguably, the most important task for the futures market is price discovery of the underlying commodity. As market participants buy and sell futures contracts, a consensus price of the good for a specific date in the future is determined. For the typical sale of physical grain, the cash price farmers receive will be equal to the current price of the nearby contract plus basis, which is the difference between the local cash and futures price. The basis should represent local supply and demand and the cost of transportation to an end user or delivery location. When nonconvergence is present, the price of futures contracts during the delivery period differs significantly from the cash price of the commodity. Adjemian, et al. (2013) argue that nonconvergence causes the price discovery function of the futures market to fail, as the futures price does not accurately represent the actual price of the physical commodity.

Producers and consumers of commodities use futures contracts and options to manage price risk by offsetting their cash position with an opposite futures position, known as hedging. Using futures to manage price risk, market participants are still subject to basis risk; however, basis has historically been more predictable than prices, and thus, basis risk is less risky than price risk. When futures markets are working properly, the expected net price resulting from hedging a commodity is equal to the futures price when the hedge was initiated plus expected basis. This effectively locks in a price for the commodity, and when basis is predictable, producers can eliminate price risk while taking advantage of expected improvements in basis. Adjemian et al. (2013)

explain that when nonconvergence is present, the value of the hedge is diminished because basis is no longer predictable, resulting in a higher risk premium because of a reduction in the probability of attaining the expected net price.

Predictability of basis helps to explain how futures markets produce storage signals. Basis varies by location and accounts for local supply and demand shifters as well as transportation costs to the nearest load-out facility. Irwin et al. (2008) explain that in a well-functioning futures market, basis is perfectly predictable at delivery points. When basis is predictable, Irwin et al. (2008) explain that holders of physical grain will store the grain if the cash price is under the futures with the expectation that cash price will rise to the futures price at the contract's expiration, resulting in an even basis. Figure 1, from Irwin et al. (2008), illustrates this concept of perfect predictability of basis at delivery locations. Another storage signal produced by the futures market comes from the nearby spread. If the difference in price between the nearby and deferred contract is greater than the cost to store the grain, owners of the physical commodity will store the grain with the expectation of realizing a better net price for the commodity in the future.

This paper will focus on local cash prices for wheat deliverable against the Chicago Board of Trade's (CBOT) Kansas City hard red winter (HRW) wheat contract across the state of Kansas since 2004. The objective of this paper is to determine spatial patterns in the rate of change of basis and the effect of nonconvergence on basis for cash bids of HRW wheat in Kansas. The results of the study are presented and discussed in a manner to allow producers and farm managers working with them to better understand wheat basis movements in their area (spatially across Kansas), in order to reduce basis uncertainty and maximize profits during a financially difficult period. This is accomplished using simple formulas and easily attainable data to provide a tool to every producer.

NONCONVERGENCE

The specific cause of nonconvergence is debatable; however, the prevailing theory is associated with inefficiencies created by the fixed storage rates on delivery instruments. Delivery against an HRW wheat contract is done with a delivery instrument in lieu of the physical grain. Prior to the MAR '18 contract, warehouse receipts were the instrument used in the delivery process. Warehouse receipts give ownership of the contract-specified quantity (5,000 bu/contract) and quality of grain to the holder of the receipt and require the grain to be stored in the regular facility that issued the receipt. Moreover, regular facilities could only issue warehouse receipts for grain they had in inventory, limiting the number of outstanding warehouse receipts to the storage capacity of regular facilities. With the MAR '18 contract, the CBOT made significant changes to the HRW wheat contract including the switch from warehouse receipts to shipping certificates. The amendments to the HRW wheat contract can be found in the CME Group's Special Executive Report 7923 (CME Group 2017). As Garcia, Irwin, and Smith (2014) explain, shipping certificates allow the regular facility a higher level of flexibility with their physical storage because, unlike warehouse receipts, they do not require the issuing regular facility to maintain the grain in storage, thus the number of outstanding shipping certificates is not limited by storage capacity. However, if the holder of the shipping certificate demands load-out, the regular facility that issued the shipping certificate must source the grain within a specified period.

Grain handling facilities must meet the requirements laid out in rule 703 of the CBOT rulebook in order to become a regular facility (CME Group 2018). The regular facilities in the HRW wheat contract are located within the switching limits of Kansas City, Hutchinson, Salina/Abilene, and Wichita. Only regular facilities can create new delivery instruments; however, as Irwin et al. (2011) explain, if other shorts are holding a delivery instrument, either through purchasing an outstanding delivery instrument or from being delivered upon previously, they can also initiate the delivery process.

The load-out process converts delivery instruments into physical grain and links the futures and cash prices. When a long demands load-out, the regular facility that issued their delivery instrument mixes, grades, and loads the grain according to the long's instructions, which, as Irwin et al. (2011) explain, inflates demand in the cash market and raises the cash price. The long pays a load-out fee to cover the costs of load-out to the regular facility and is responsible for the transportation of the grain after the load-out process. The costs of load-out attributes to the costs of delivery against the futures contract. Irwin et al. (2011) calculated the cost of delivery to be 8 cents per bushel for all CBOT grain contracts based on a 6-cent barge load-out fee, and a 2 cent fee for other costs including grading and blending the grain.

Adjemian et al. (2013) attributes the lack of convergence in grain futures markets to the disconnect between storage rates for the physical commodity and the storage rates for the delivery instrument specified in the commodity's contract. Delivery instruments can be held indefinitely if daily storage fees are paid in accordance to rule 14H08, located in the KC HRW Wheat Futures chapter of the CBOT rulebook (CME Group 2018). Prior to the MAR '18 contract, the storage rate on warehouse receipts was fixed, albeit with a seasonal adjustment to account for storage availability concerns in the post-harvest contract months. This could lead to the creation of a "wedge" between the cost of physical storage and the cost of storing a delivery instrument, as demonstrated by Garcia, Irwin, and Smith (2014). Their study found a strong positive correlation between the wedge and ending stocks at delivery locations, implying that the lack of available physical storage can lead to nonconvergence. Figure 2 shows how a lack of available storage can create a wedge in the short run. At S_0, the storage market is in equilibrium, where the price of physical storage is equal to the cost of storage for the delivery instrument. If the supply of available storage decreases, ceteris paribus, the cost of physical storage will increase; however, because delivery instrument's storage rates are fixed by the CBOT, the cost of physical storage now exceeds the cost of storing the delivery instrument. Holders of delivery instruments are incentivized to store their delivery instruments rather than going through the load-out process and storing the physical commodity. Thus, a disconnect between the cash and futures market is probable. The CBOT has recognized the inefficiencies caused by fixed storage rates on the delivery instruments and implemented a variable storage rate (VSR) in the soft red winter (SRW) wheat contract in 2010 and more recently in the HRW wheat contract in 2018. The VSR adjusts the storage rate on shipping certificates to align with the cost of carrying the physical grain.

THEORETICAL MODEL

While the causes of nonconvergence at delivery locations are well documented, the effects of nonconvergence on cash prices at non-delivery locations are under-researched, especially for the HRW wheat contract. Karali, McNew, and Thurman (2018) modeled basis at non-delivery locations around Toledo, Ohio, as a percentage of basis at the delivery location for SRW wheat plus a location-based fixed effect to account for transportation costs and local supply and demand factors from the MAR '05 contract through the MAY '13 contract. This allowed them to determine the rate of basis movement at non-delivery locations relative to the delivery point. For the contract months analyzed by Karali, McNew, and Thurman (2018), there was only one period of nonconvergence; from the MAY '08 to the DEC '09 contracts. The CBOT introduced the VSR mechanism in the SRW wheat contract in 2010; after which, nonconvergence was not present. As a result, Karali, McNew, and Thurman (2018) analyzed three time periods: pre-nonconvergence, nonconvergence, and post-nonconvergence. They found that during periods of nonconvergence, on average, basis at non-delivery locations follows changes in basis at the delivery location more closely than the previous period of convergence, signaling a disconnect of futures and cash prices throughout the studied area. Moreover, in the post-nonconvergence period, basis co-movement decreased to levels similar to the pre-nonconvergence period.

DATA

Daily cash closing prices, from Jan. 2, 2004, to July 13, 2018, were collected for #1 hard red winter wheat at 90 grain handling facilities from DTN's ProphetX database. The prices represent the amount the elevator is willing to pay per bushel of #1 HRW wheat and do not include any premiums or docks for qualities such as moisture levels and protein. These locations were chosen based on data availability and represent five regular facilities in delivery locations Salina, Abilene, and Hutchinson; two non-regular facilities in delivery locations Hutchinson and Wichita; USDA daily grain bids for Dodge City, Garden City, Goodland, and Kansas City, Missouri; and 79 elevators in non-delivery locations throughout Kansas. The selected locations for cash prices are clustered more densely in the central part of the state where production of HRW wheat is highest, as shown in Figure 3. Wheat production numbers are based on NASS statistics from 2004–2017 (USDA-NASS 2018). Observations with missing prices were removed from this study resulting in an uneven panel data set.

Basis for each location was calculated by subtracting the nearby futures price from the respective cash price for each day and is measured in dollars per bushel. Kansas City was chosen as the base for comparisons over the other delivery locations because of its barge loading facilities on the Missouri River and the ease of transport to the Gulf of Mexico for export. Deliveries at Kansas City occur at the par value of the contract, as shown in rule 14H05 in the KC HRW Wheat Chapter of the CBOT Rulebook (CME Group 2018). To determine the periods of nonconvergence, the average basis at Kansas City during the delivery period of each contract was calculated. Regarding the load-out costs, estimated at $0.08 by Irwin et al. (2011), any contract with an average delivery period basis at Kansas City less than 8 cents under par value is considered nonconvergent. Only cash-under-futures nonconvergence is considered because of its pervasive nature in the analyzed period. Of the 73 studied contracts, 44 contracts exhibited nonconvergence. The average basis at Kansas City during the delivery period is plotted in Figure 4. Points below the orange line denote nonconvergence.

EMPIRICS

A model was developed to calculate expected basis at each location, given basis in Kansas City the previous day. Hauser, Garcia, and Tumblin (1990); Taylor, Dhuyvetter, and Kastens (2006) determined that expected basis can be modeled adequately using naïve pricing, further supporting its use in this study. The model used to find expected basis is given by:

(1) $$b_{ikt} = FE_i + CM_j + \delta_i b^{KC}_{kt-1} + \gamma_i D^{nonconvergence}_k$$

Where:

i= 1, ... , 90 (grain handling locations)

j= 1, ... , 5 (nearby contract month, i.e. March, May, July, September, December)

k= 1, ... , 73 (all contracts from March 2004–July 2018)

t= 1, ... , 3250 (date)

The dependent variable, represented by b_{ikt}, is equal to the basis ($/bu) at location i for contract k on day t. FE_i represents the fixed effects for location i. CM_j is a dummy variable for the contract month j to control for seasonality differences in basis. b^{KC}_{kt-1} is the basis ($/bu) at Kansas City for contract k on day t-1. Basis at Kansas City is lagged to allow the various locations to react to a change in basis at the delivery location using the assumption that elevator managers look at basis in Kansas City at the end of the day and adjust basis at their location accordingly. D^{noncon}_k is a dummy variable denoting the presence of nonconvergence in contract k. The coefficient δ_i measures the basis at location i as a percentage of basis at Kansas City. The coefficient γ_i measures the change in basis at location i when non-convergence is present.

Location-based fixed effects were included in the model to account for transportation cost differentials and local supply and demand factors. The location-based fixed effect allows for a fair comparison of the basis co-movement values between locations. Kansas City is the base value with which the rest of the locations are compared. Therefore, the fixed effects coefficients can be thought of as the expected basis at location i given basis at Kansas City is equal to zero during any given July contract.

The contract month dummy variable controls for seasonal patterns in basis and prevents biasing the effects of nonconvergence. The July contract is omitted to be used as the base because of its temporal alignment with the majority of HRW wheat harvest throughout the state. The cyclical nature of grain production, in conjunction with supply and demand, theoretically dictates that local basis will be weakest during or immediately after harvest. The increased supply of grain following harvest will depress local prices, thus weakening basis. As grain is moved from the location, supply will dwindle, and local basis should strengthen until the next harvest.

The basis co-movement coefficient measures the magnitude of a change in basis at location i as a percentage of a change in basis at Kansas City the previous day. In a period of convergence, the rate of change in basis at location i given a change in basis in Kansas City is equal to δ_i . Therefore, the expected basis during a period of convergence at location i given a change in basis in Kansas City the previous day can be determined using the formula:

(2) $$Eb_{ikt} = b_{ikt-1} + \delta_i * \Delta b^{KC}_{kt-1}$$

The most interesting coefficient is the change in basis because of nonconvergence. This coefficient will explain how basis at non-delivery locations is affected by nonconvergence. In a period of nonconvergence, the expected change in basis at location i given a change in basis at Kansas City can be calculated using the formula:

(3) $$\Delta b_{ikt} = \delta_i * \Delta b^{KC}_{kt-1} + \gamma_i$$

Lastly, the expected basis during a period of nonconvergence at location i given a change in basis in Kansas City the previous day is calculated using the formula:

(4) $$Eb_{ikt} = b_{ikt-1} + \delta_i * \Delta b^{KC}_{kt-1} + \gamma_i$$

RESULTS

The model shown in Equation 1 is estimated using OLS regression with White-Huber standard errors to account for heteroskedasticity present in the data set. A summary of the regression results is shown in Table 1. Full results are available from the authors upon request. As expected,

CM_j, summarized in Table 2, shows that basis is expected to be weakest during the July contract months, reinforcing the theory that basis is weakest during and immediately following harvest. On average, basis is expected to be $0.048 per bushel higher for a contract other than the July contract. The rest of the coefficients are then matched to their respective locations. These values are then interpolated across space using the kriging method and discussed through Figures 5–9 below.

Figure 5 shows the interpolated results for the fixed effects coefficients. These values can be interpreted as the expected difference between basis at each location and basis at Kansas City. The highest values of fixed effects are clustered around delivery locations and decrease as the distance to the closest delivery location increases. The inverse relationship between the expected difference in basis and distance to a delivery location demonstrates the theory that transportation costs to a delivery location are a major factor in determining cash prices in outlying markets. Moreover, the difference in fixed effects between a regular facility and a non-regular facility in the delivery location of Hutchinson, Kansas, is $0.18 per bushel, indicating that regular facilities offer a higher cash price than their non-regular counterparts.

For each studied location, basis as a percent of Kansas City's basis is significantly greater than 0 and significantly less than 1, with a range between 72.5 percent and 92.1 percent. This suggests that the rate of basis change in outlying locations has the same direction of change as basis at Kansas City, but at a reduced rate. When analyzed spatially, shown in Figure 6, the northern half of the state exhibits higher rates of co-movement with Kansas City's basis than the southern half. This implies Kansas City is the most convenient barge load-out facility for the northern areas of the state, while the southern areas look elsewhere, most likely Tulsa, Oklahoma. Thus, it is sensible to assume that the southern parts of the state would exhibit a weaker connection to basis changes in Kansas City than areas that haul grain to Kansas City to be loaded for export.

Nonconvergence was estimated to have an effect on basis between −$0.121 and $0.005 per bushel. Figure 7 displays the effects of nonconvergence on basis in dollars per bushel. It is readily apparent that nonconvergence had a lesser effect on basis at locations near delivery points in the middle of the state, suggesting that the shortage of available storage that created nonconvergence in Kansas City does not necessarily mean nonconvergence is occurring in other delivery locations. Figure 8, using data collected by the Arthur Capper Cooperative Center, shows storage capacity of grain handling facilities, both cooperative and noncooperative, in Kansas by county. Storage capacity is largest in the area where nonconvergence had the least effect on basis. The larger storage capacity in this area should minimize storage availability concerns and dampen the cause of nonconvergence. When nonconvergence is present at Kansas City, 50 of the 90 locations studied exhibited a statistically significant decrease in expected basis. Figure 9 displays a Bayesian krig of the significance of the effect on nonconvergence on basis. The results from the Bayesian krig can be interpreted as the probability that nonconvergence has a significant effect on basis. Unsurprisingly, the areas that exhibited the lowest effect of nonconvergence were also least likely to exhibit a statistically significant impact on basis. Areas with a low probability of significance are unlikely to observe an effect on basis attributed to nonconvergence.

IMPLICATIONS

The purpose of this study was to inform farm managers of spatial patterns in factors influencing basis across the state of Kansas. Geospatial mapping of cross-sectional time series data demonstrated how basis patterns varied across the state. Naïve pricing allows producers to easily calculate expected changes in basis with readily available data to improve their marketing strategies. This study reaffirmed the economic theory that basis is linked to transportation costs by analyzing the location-specific fixed effects. Though this is not new information, it helps explain the price disparity between locations throughout the state. Similarly, nonconvergence has a lessened effect on basis in areas with more grain storage and locations near delivery locations. This is likely part of the explanation behind the weaker connection to Kansas City's cash prices of study locations in the southern half of the state compared to those in the northern half. Geospatial analysis gives a more comprehensive understanding of the effects of nonconvergence than the stand-alone results and helps producers make more informed decisions about grain marketing.

Farm managers can use the results of this study in discussions with their producers to help them understand the historical movement of basis and trends regarding location and delivery month. The geospatial mapping, shown in Figures 5, 6, and 7, allows for basis predictions to be tailored to the producer's specific locale. In areas where nonconvergence is likely to have an effect on basis, shown by the green areas in Figure 9, farm managers should prepare for a wider spread between Kansas City's price and their local price when nonconvergence is occurring, resulting in weaker-than-normal basis. This could create an opportunity for producers to gain a higher realized price through basis improvements with a storage hedge, for example, if the markets converge in a timely matter; however, depending on the producer's risk preference, basis risk from the increased volatility could offset any potential gains in basis improvement. Producers should also be cognizant of the risk of nonconvergence beginning while they are entered into a storage hedge, which could result in lower than expected basis improvements and a lower realized net price.

It is important for all users of both cash and futures markets to understand the underlying price and/or basis risk they may be facing. Using the results from this study, producers and farm managers can better predict changes in their local basis and adapt their marketing strategies to fluctuating market conditions. Future work will be done in this area to examine the impact of variable storage rates and the shift to shipping certificates on the hard red winter wheat futures market.

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APPENDIX

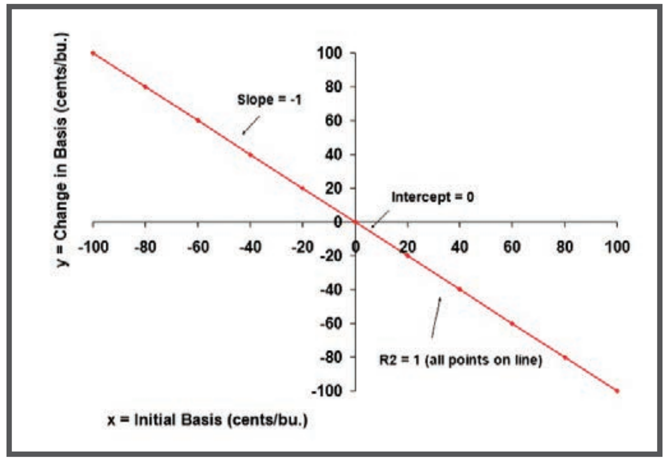

Figure 1. Perfect Basis Predictability

Source: Irwin et al. (2008)

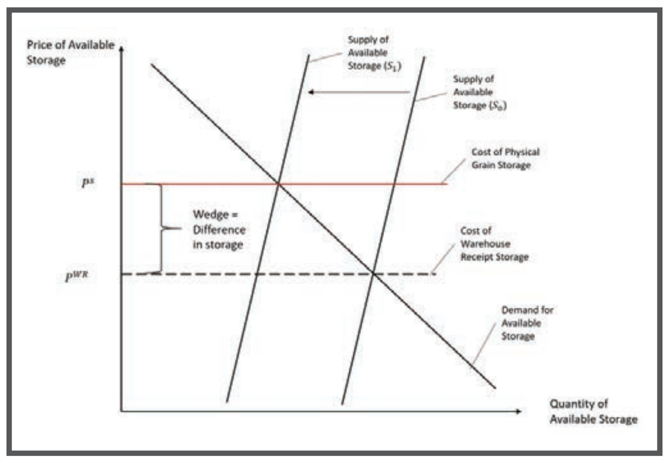

Figure 2. Wedge Creation from Lack of Available Physical Storage

Source: Irwin et al. (2008)

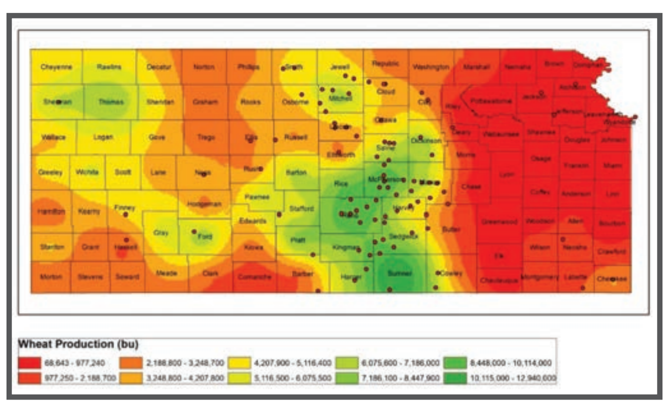

Figure 3. Average HRW Wheat Production, 2013–2017

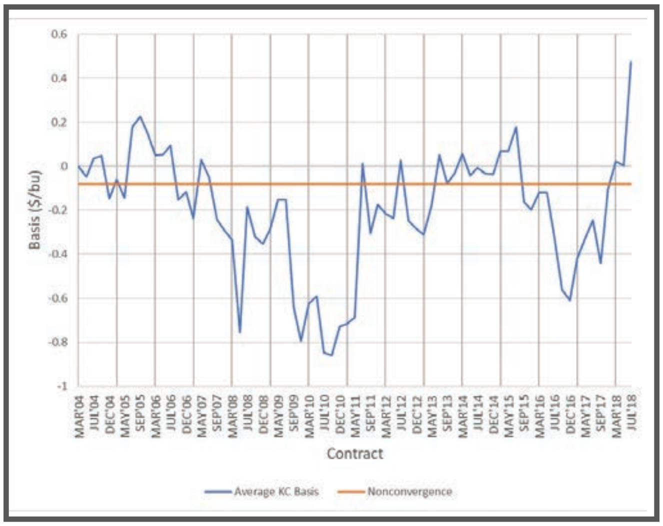

Figure 4. Average HRW Wheat Basis During the Delivery Period at Kansas City, MO

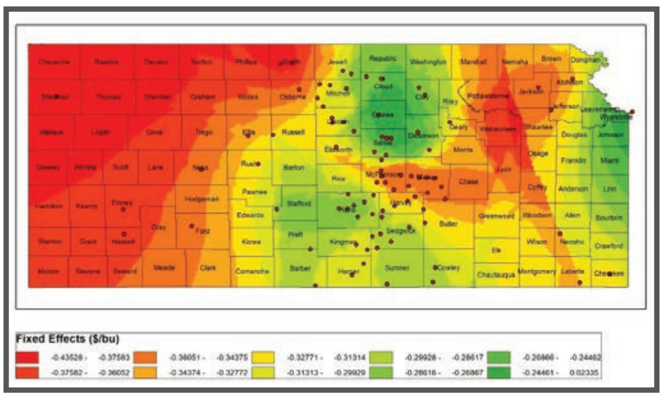

Figure 5. Fixed Effects

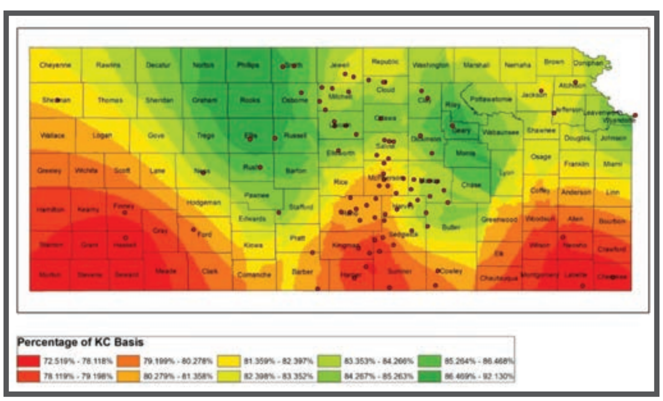

Figure 6. Basis as a Percent of Kansas City, MO Basis

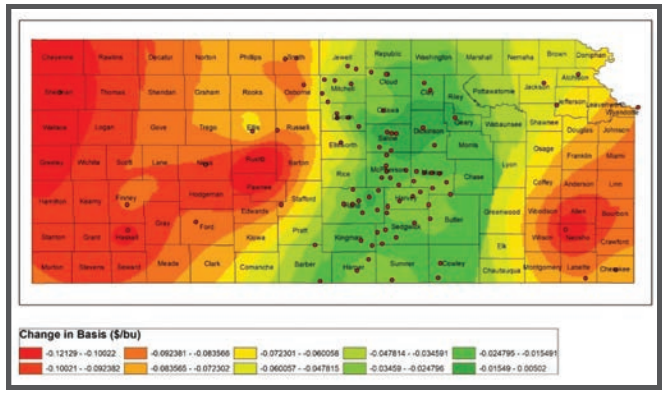

Figure 7. Effect of Nonconvergence on Basis

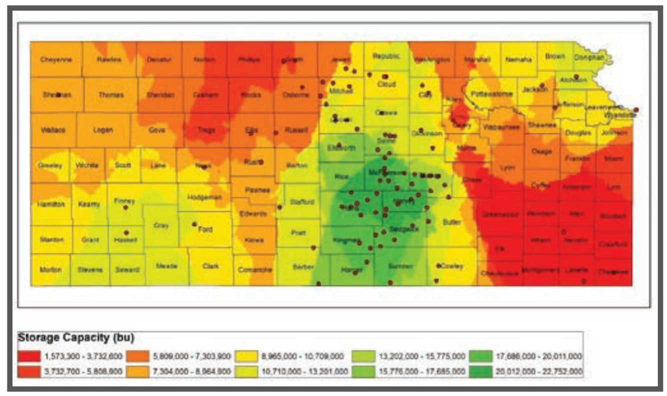

Figure 8. Grain Storage Capacity

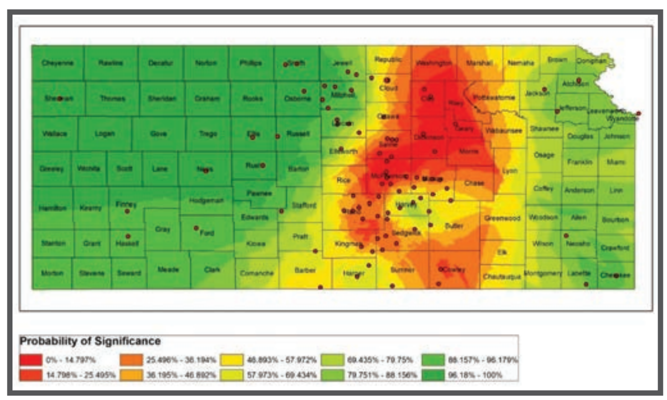

Figure 9. Significance of Effect of Nonconvergence on Basis

Table 1. Summary of Regression Results

	Coefficients			
	Fixed Effects	**Contract Month**	**Comovement**	**Nonconvergence**
n	89	4	90	90
Mean	-0.31418	0.04809	82.375%	-0.03802
Min	-0.43528	0.02285	72.519%	-0.12129
Max	0.02335	0.06310	92.130%	0.00502
10th percentile	-0.37478	0.03184	78.087%	-0.08371
90th percentile	-0.26169	0.06025	87.168%	-0.01688
Counts:				
Significantly >0	1	4	90	0
Significantly <0	88	0	0	50
Number >0	1	4	90	1
Number <0	88	0	0	89
Significantly =/=0	89	4	90	50

Prob > F = 0
R-squared = 0.9008

Table 2. Seasonality of Basis

Contract Month	Coefficient	Standard Error	t-value	P-value
March	0.0630998	0.0011379	55.45	0
May	0.0535986	0.0011762	45.57	0
July	0	N/A	N/A	N/A
Sep	0.0228501	0.001253	18.24	0
Dec	0.0528253	0.0011415	46.28	0